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OPERATING CHARACTERISTIC CURVES
FOR
SAMPLES FROM A BINOMIAL POPULATION

PRODUCT ASSURANCE DIVISION

TECHNICAL REPORT AFATL-TR-72-174

AUGUST 1972

APR 13 1973

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**Operating Characteristic Curves
for
Samples from a Binomial Population**

**Mark O. Glasgow
Russell R. Ratcliff**

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FOREWORD

The work reported in this technical report was undertaken in support of reliability and quality assurance functions and was done during the period October 1971 to July 1972.

Digital computer services in support of this effort were provided by the Computer Sciences Laboratory (TSX), Eglin Air Force Base, Florida.

Significant assistance in the preparation of this report was provided by the members of the Reliability Engineering and Quality Assurance Branch (DLGR). A special acknowledgement is due to Mr. Thomas J. Psaltis of the Weapons Support Branch (TSXBW) and particularly to Mr. Cecil D. Cliburn (TSXBW) for programming the computations.

This technical report has been reviewed and is approved.



RANDALL L. FETTY, Colonel USAF
Chief, Product Assurance Division

ABSTRACT

Operating characteristic curves are presented which give the probability of a random sample from a binomial population being accepted versus the true reliability of the lot for a given sample size and with the acceptance number of defectives held fast. The curves can be used by statisticians, engineers, and quality assurance workers concerned with attributes testing of large lots of items submitted for testing or with writing specifications for such tests.

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SECTION I

INTRODUCTION

This technical report presents operating characteristic (OC) curves that give the probability, P, of a random sample from a binomial population being accepted versus the true reliability, R, of the lot, for sample size and acceptance number of defectives held fast. The graphs are for the lot tolerable percent defective (LTPD) = $p_0 = .01(.01).15$. The confidence levels, C, used are .5, .6, .7, .8, .9, .925, .950, .975, and .990. The sample defectives acceptance numbers, D, used are D = 0(1)5, 10, and 15.

The graphs should find many uses among the statisticians, engineers, and quality assurance workers who are concerned with attributes testing of large lots of items submitted for inspection, or with writing specifications for such tests.

SECTION II

ASSUMPTIONS AND FORMULAS

It is assumed that large lots are to be submitted for attribute acceptance inspection and that sample sizes, N, are small in comparison to lot sizes. With this assumption, the binomial distribution governs the probability of a random sample passing the inspection test with acceptance of the lot. If this assumption were not justified, the hypergeometric distribution would apply, rather than the binomial distribution.

Sample size, N, was computed as a function of p_0 (the lot tolerable percent deflection, LTPD), the deflection acceptance number, D, and the confidence level, C. The number, N, was selected as the least positive integer satisfying the inequality :

$$\sum_{x=0}^D \binom{N}{x} p_0^x (1 - p_0)^{N - x} \leq 1 - C$$

With the sample size thus obtained, the probability, P, that a random sample of size N would be accepted was computed as a function of true reliability, R:

$$P = \sum_{x=0}^D \binom{N}{x} (1-R)^x R^{N-x}$$

The values of P versus R were tabulated and graphed with N, C, and D as parameters. It will be noted that all the graphs on one figure pass through or very near the point $P = 1 - C$; $R = 1 - p_0$. The need to use integral values of sample size, N, in the relations for P is the reason the curves do not always pass exactly through these points.

SECTION III

EXPLANATION OF GRAPHS

Appendices I through XV present the graphs for curves for lot tolerable percent defective (p_0) = 0.01 through p_0 = 0.15. Each graph contains eight curves, one each for $D = 0, 1, 2, 3, 4, 5, 10$, and 15 . In the top portion of the graphs, the value of the defectives acceptance number, D, increases from left to right. That is, the top portion of the curve farthest to the left has $D = 0$, while the curve farthest to the right has $D = 15$. The order is reversed for the portion of the curves at the bottom of the graphs or pages. The point on the graphs where the curves intersect is $(R, P)_0 = (1 - p_0, 1 - C)$. As an example of the use of these curves, suppose the requirement were made that a product tested should have 90% reliability with 80% confidence level. The OC curves, with sample sizes and acceptance numbers for this case may be found on page 99. This graph has $p_0 = 1 - R = 0.1 - 0.900 = 0.100$, and $C = 0.80$. The curve $D = 0$ requires sample size $N = 16$; while $D = 1$ requires sample size $N = 29$, etc. The curves for larger values of D approach more closely to an ideal shape for an OC curve, but carry the penalty of larger sample requirements.

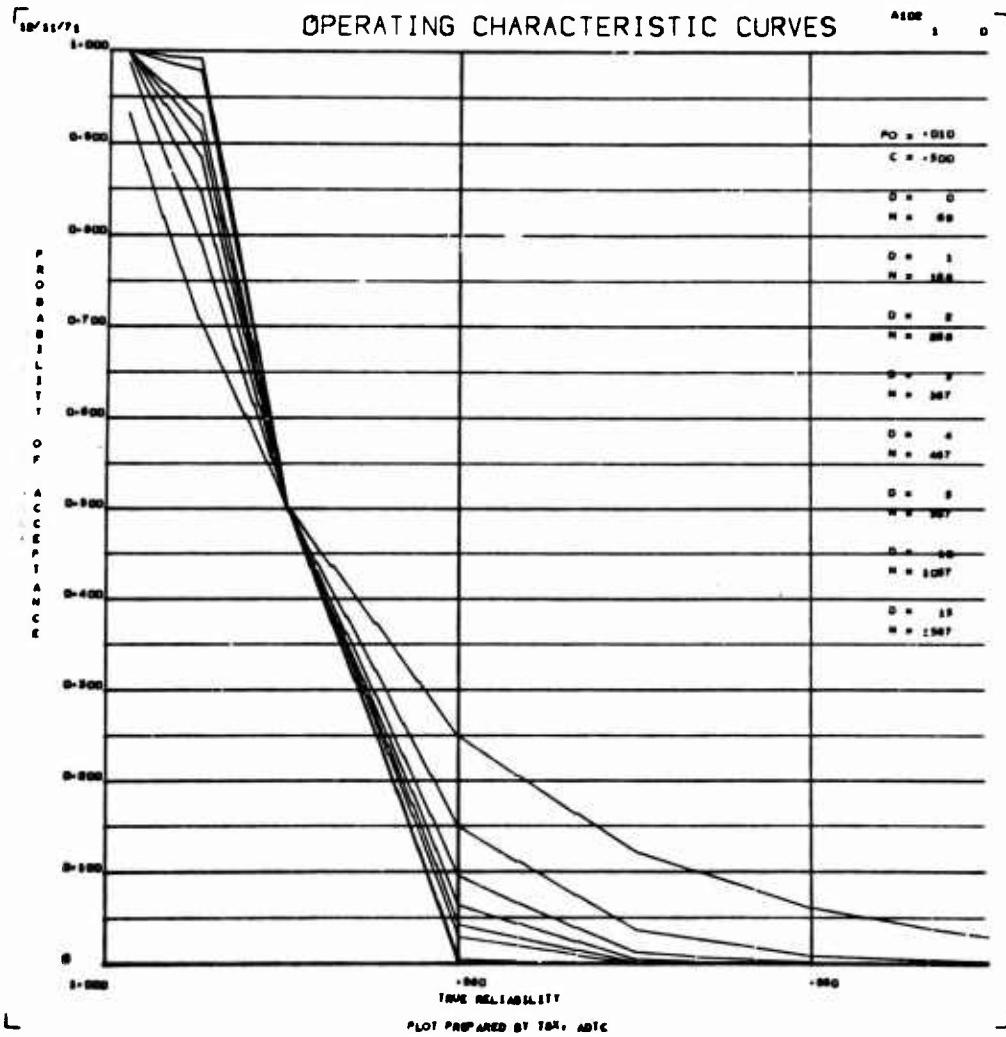
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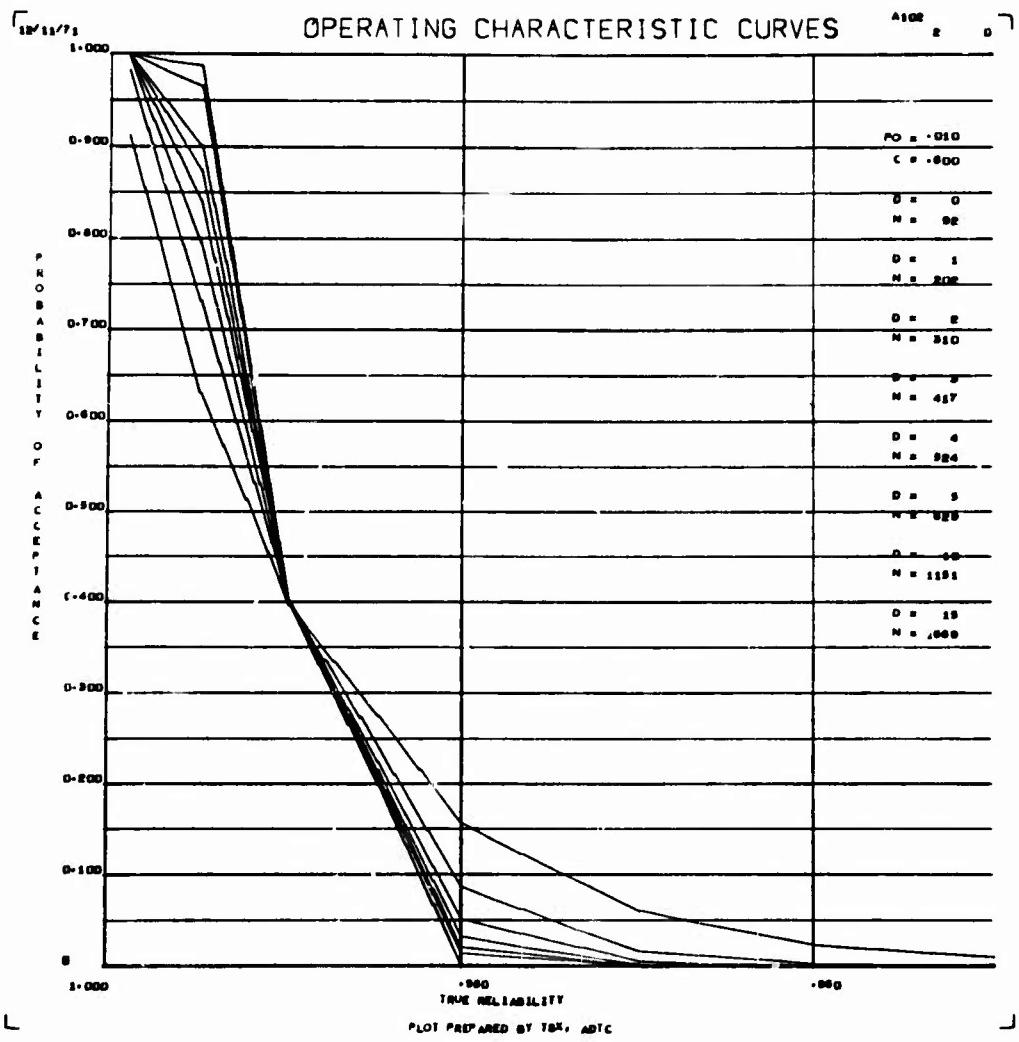
The following symbols and abbreviations are used on the graphs:

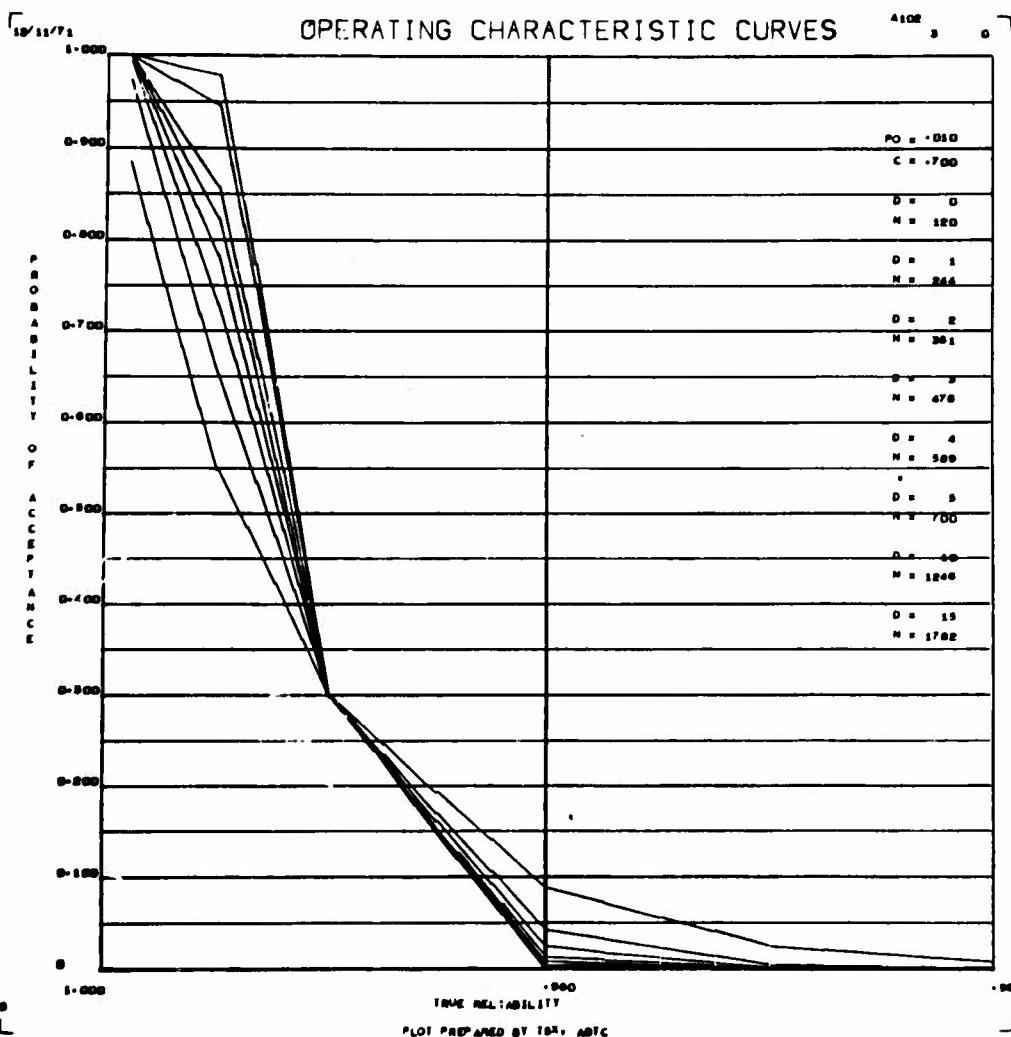
- C** Confidence Level
- D** Acceptance Number
- N** Sample Size
- P** Probability of a Sample Being Accepted
- p_0** Fraction Defective, Lot Tolerable Percent Defective (LTPD)
- R** True Reliability

APPENDIX I

**OPERATING CHARACTERISTIC
CURVES ($p_0 = .010$)**



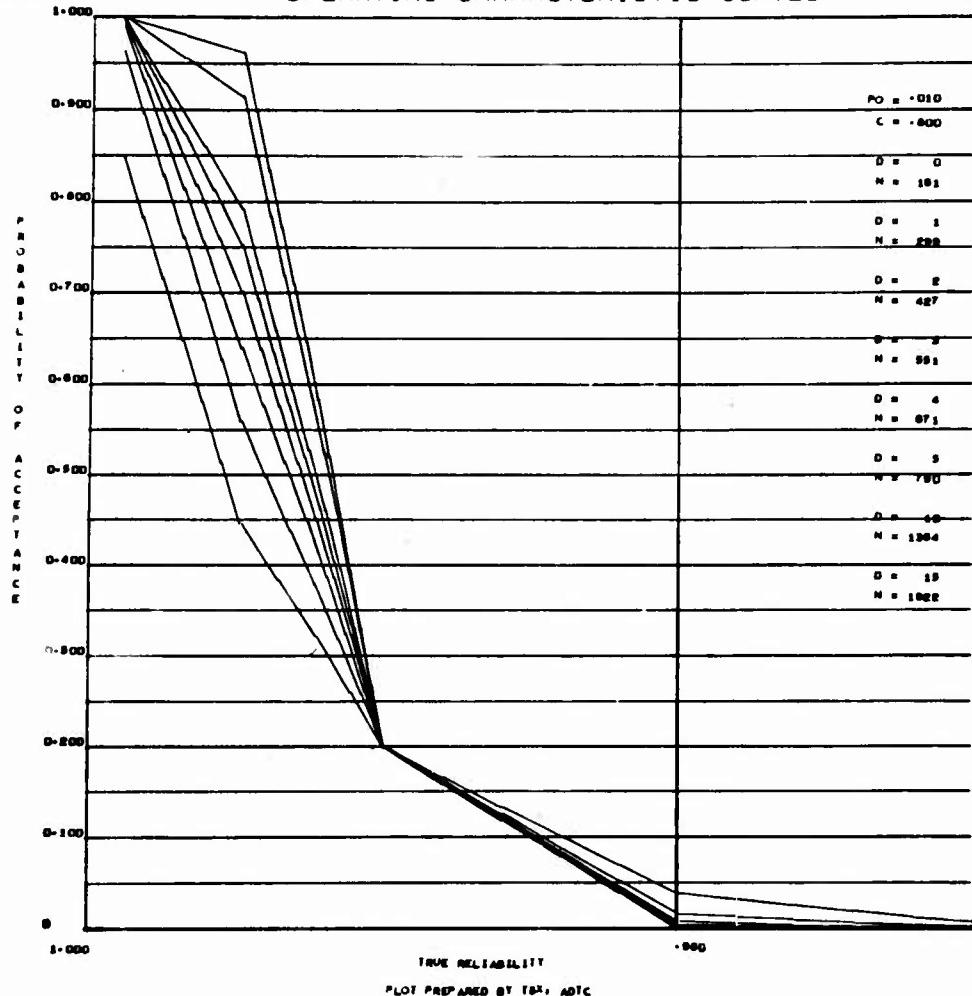




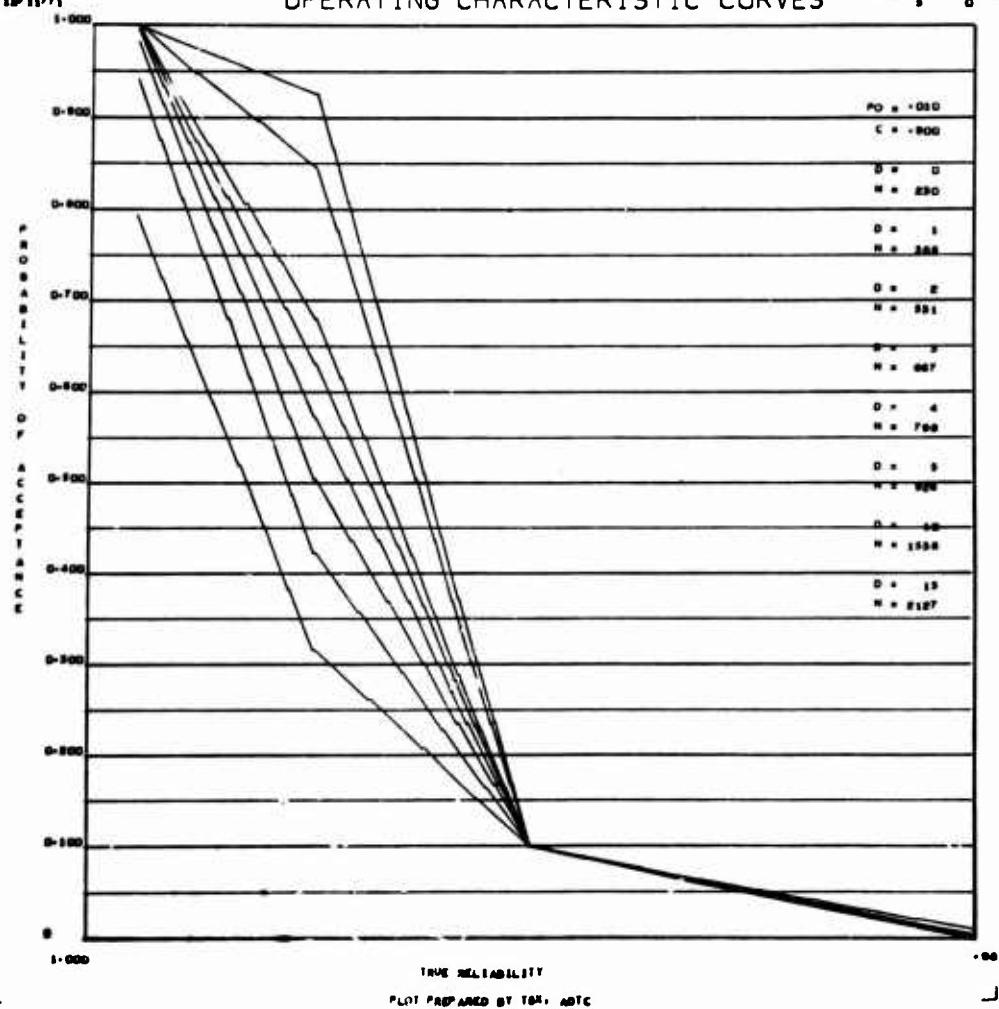
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OPERATING CHARACTERISTIC CURVES

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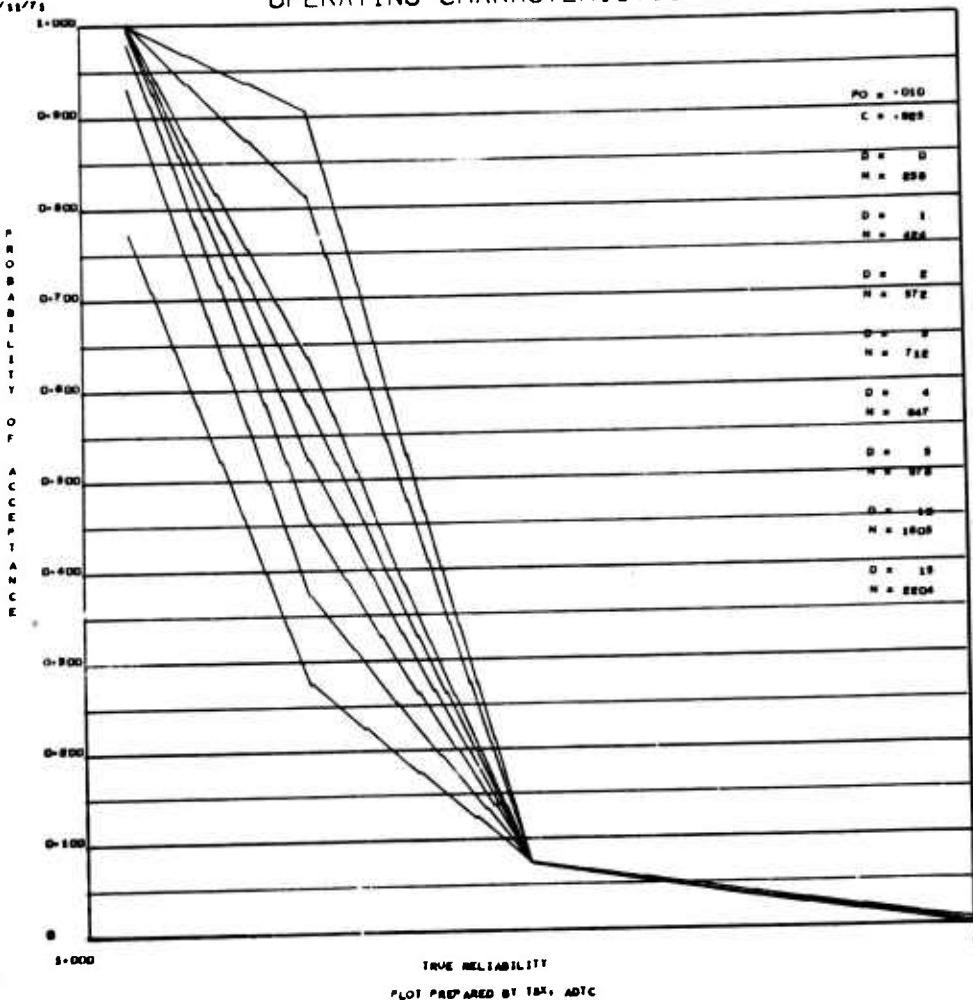
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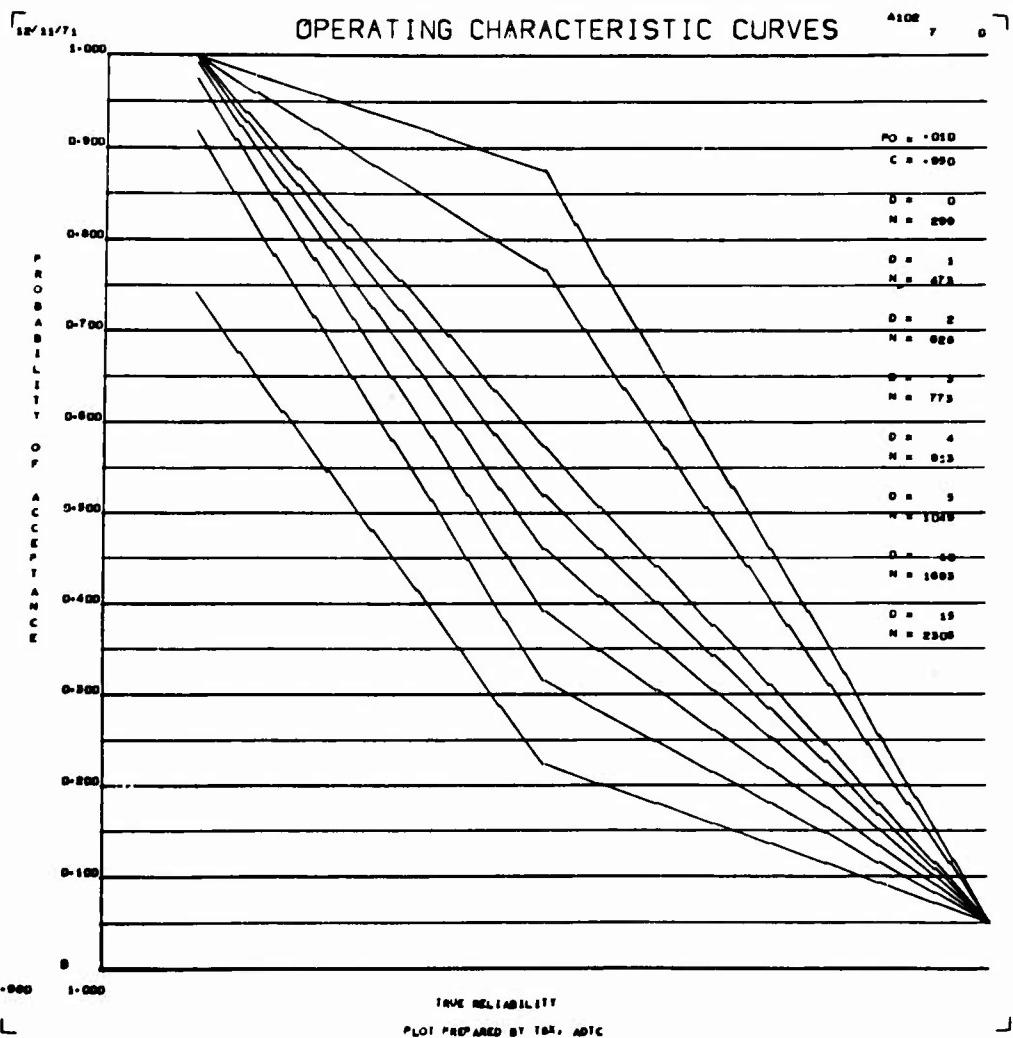


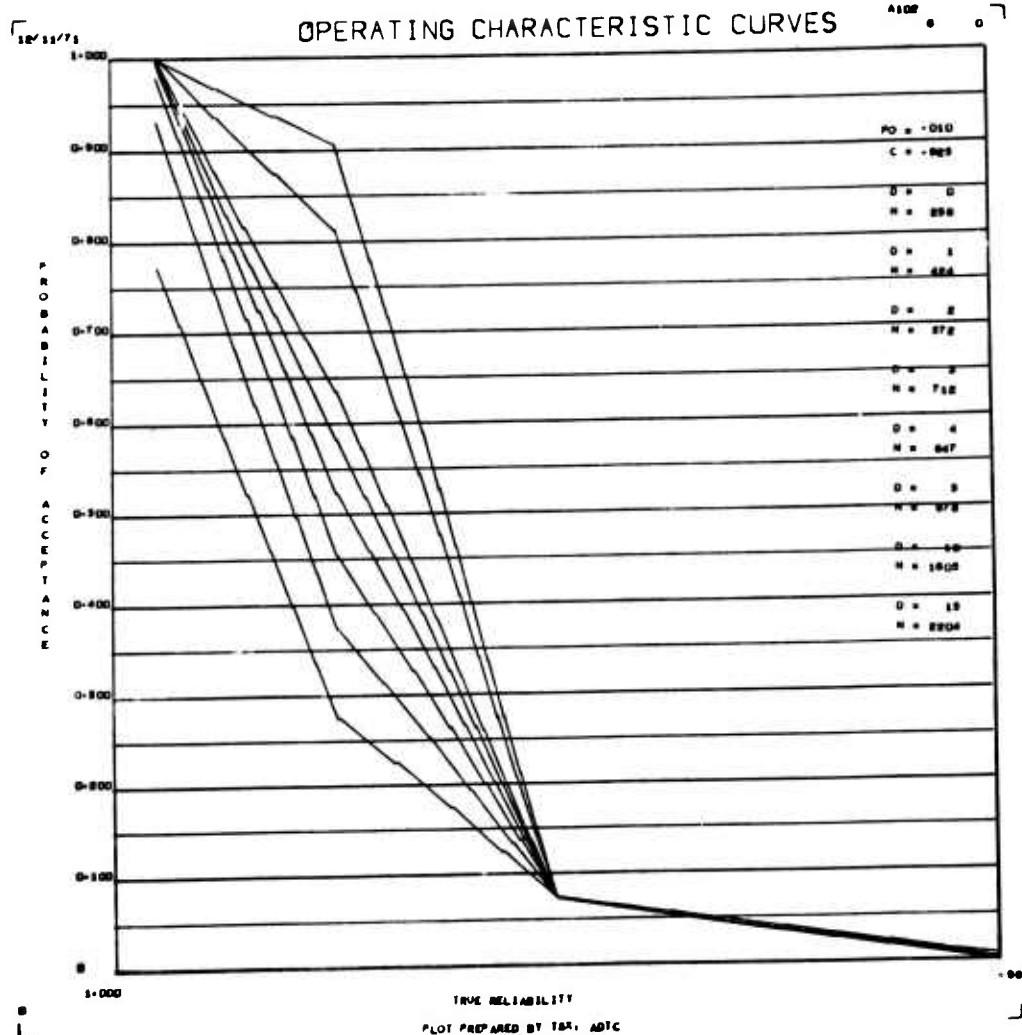
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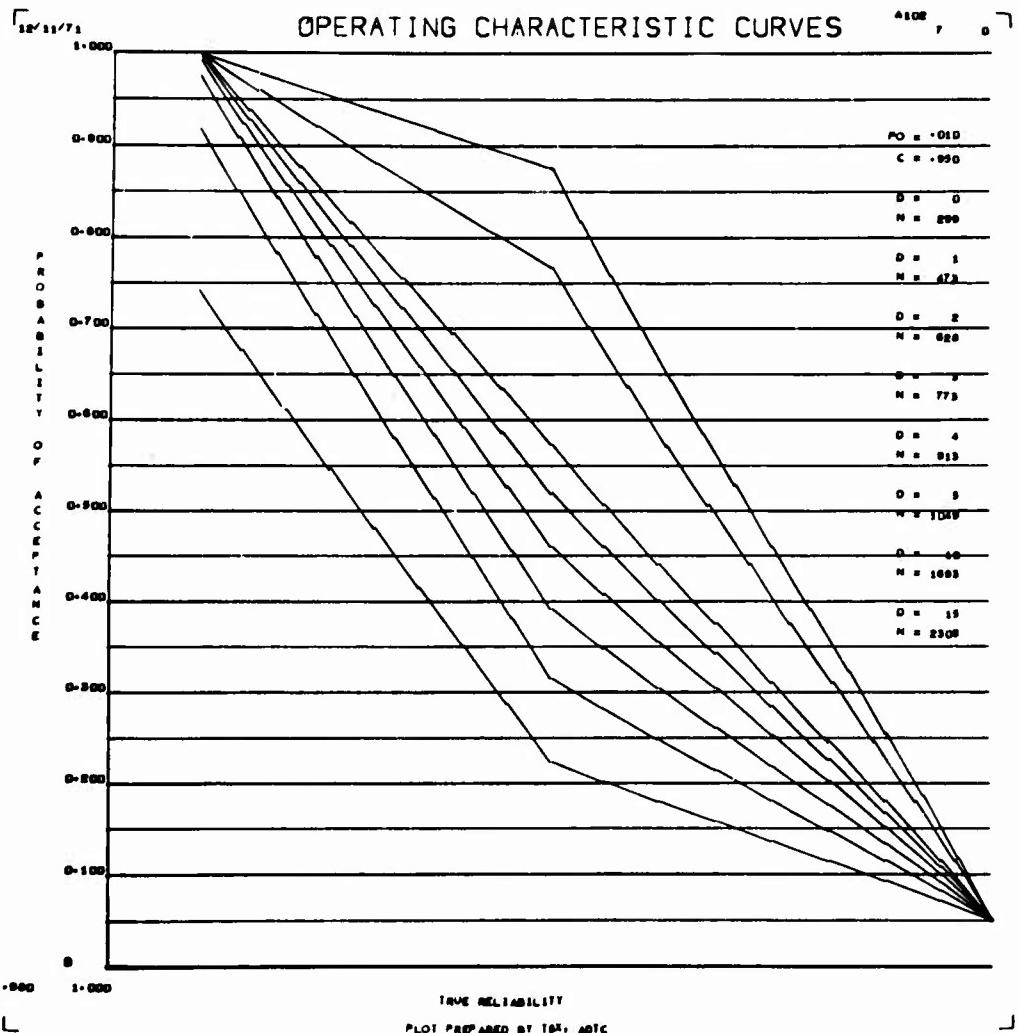
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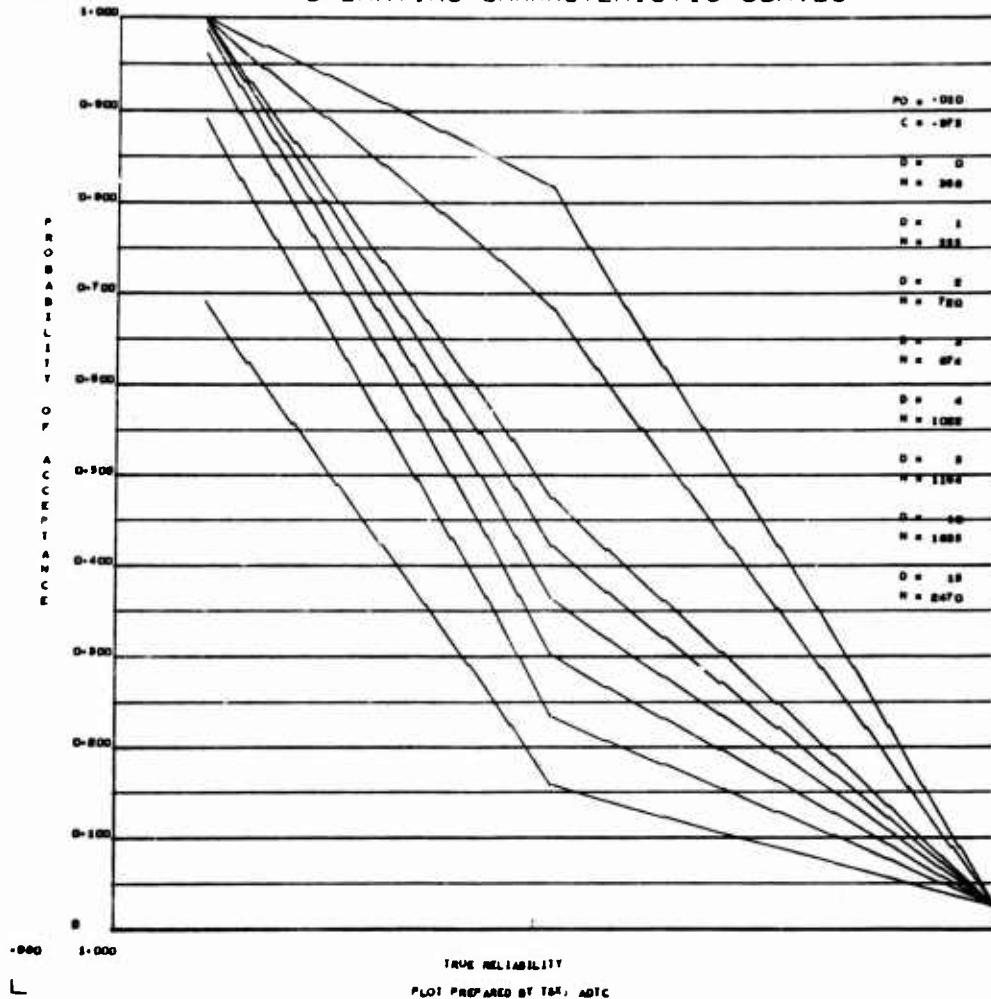






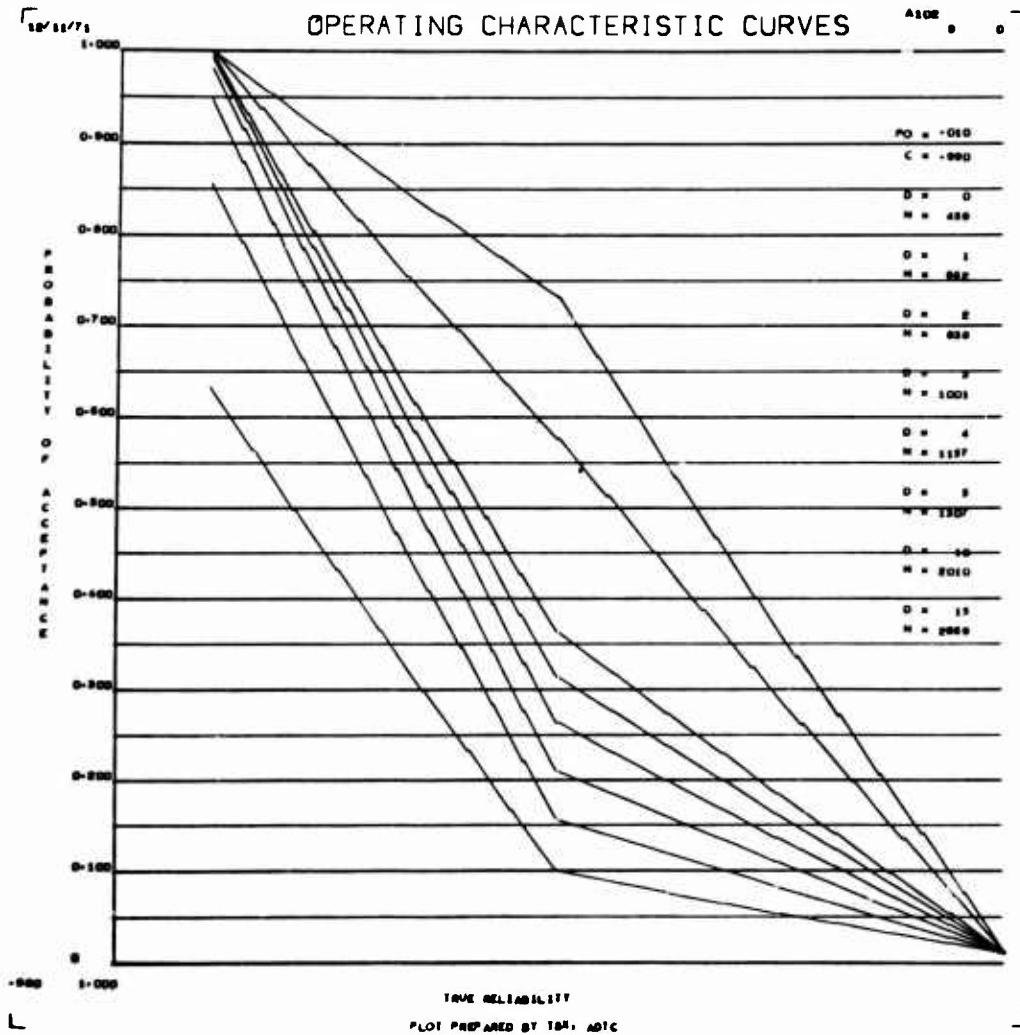


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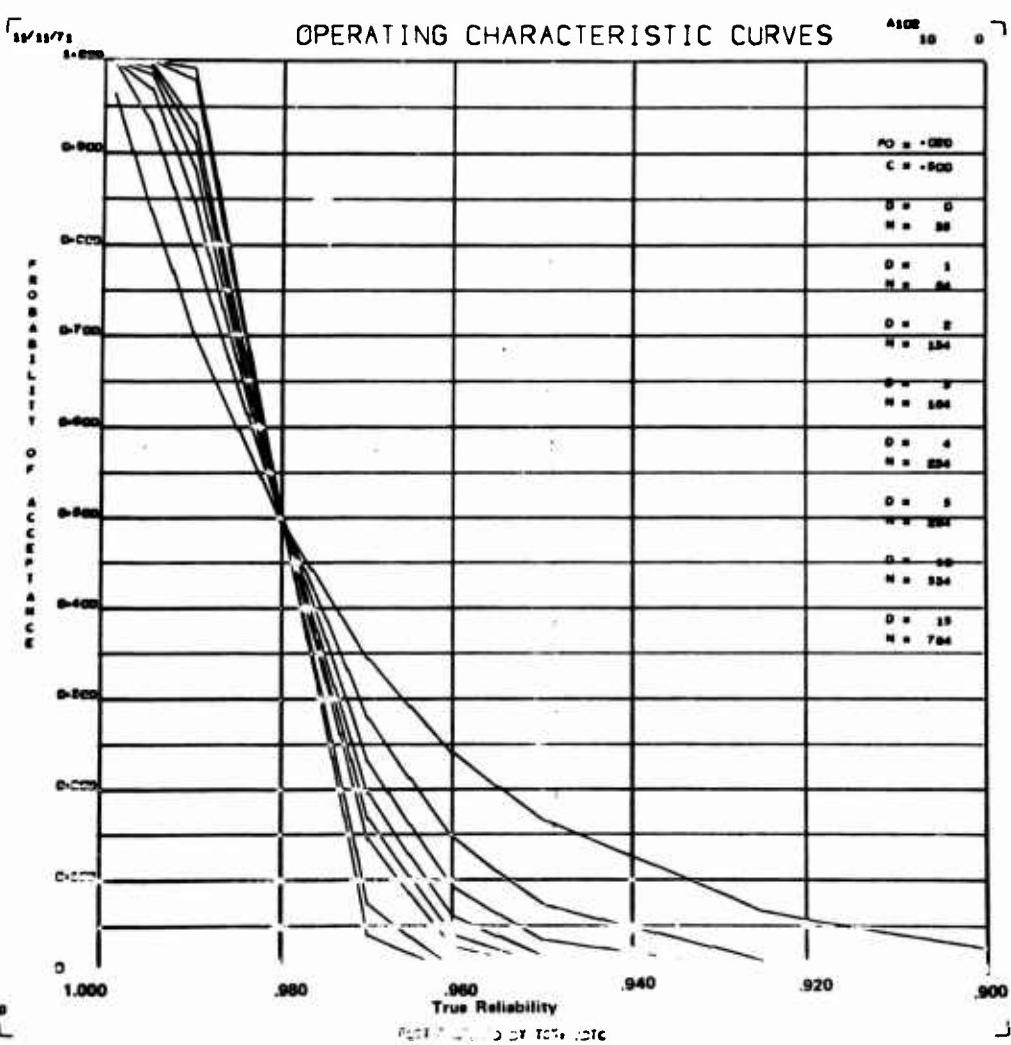
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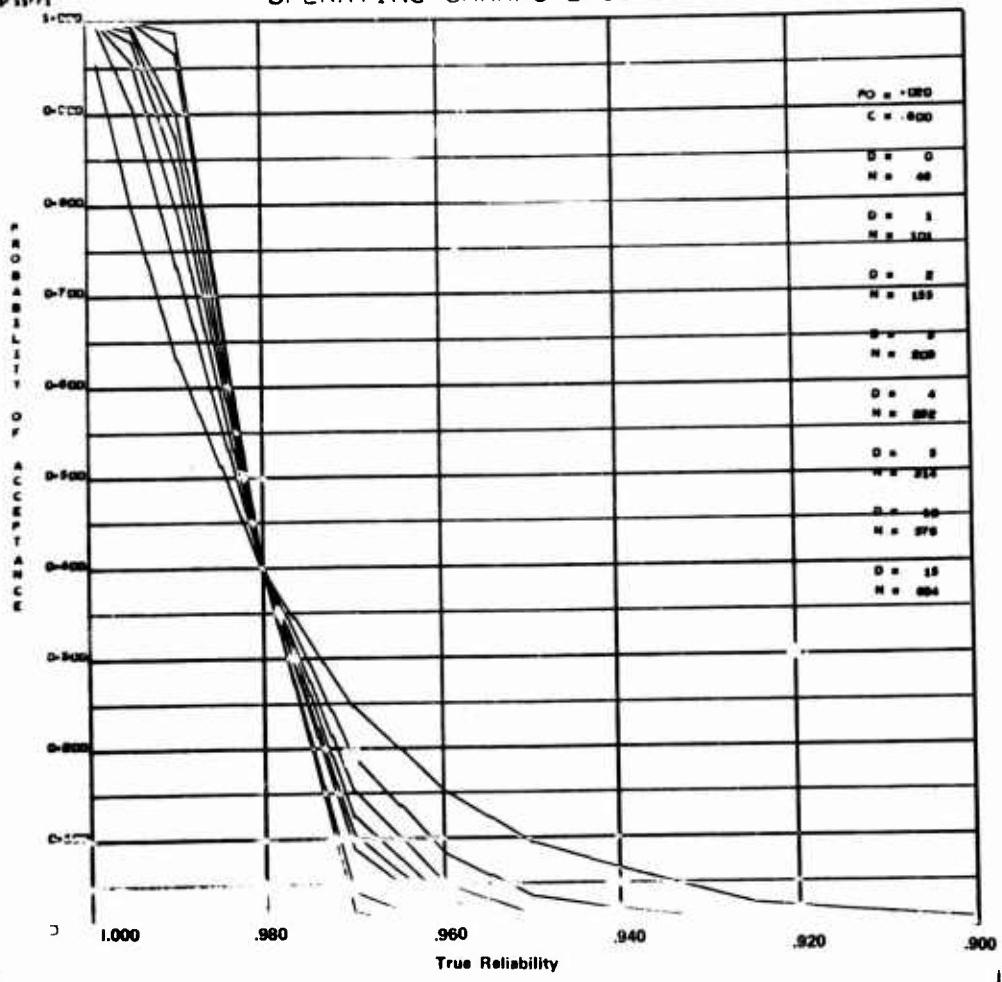


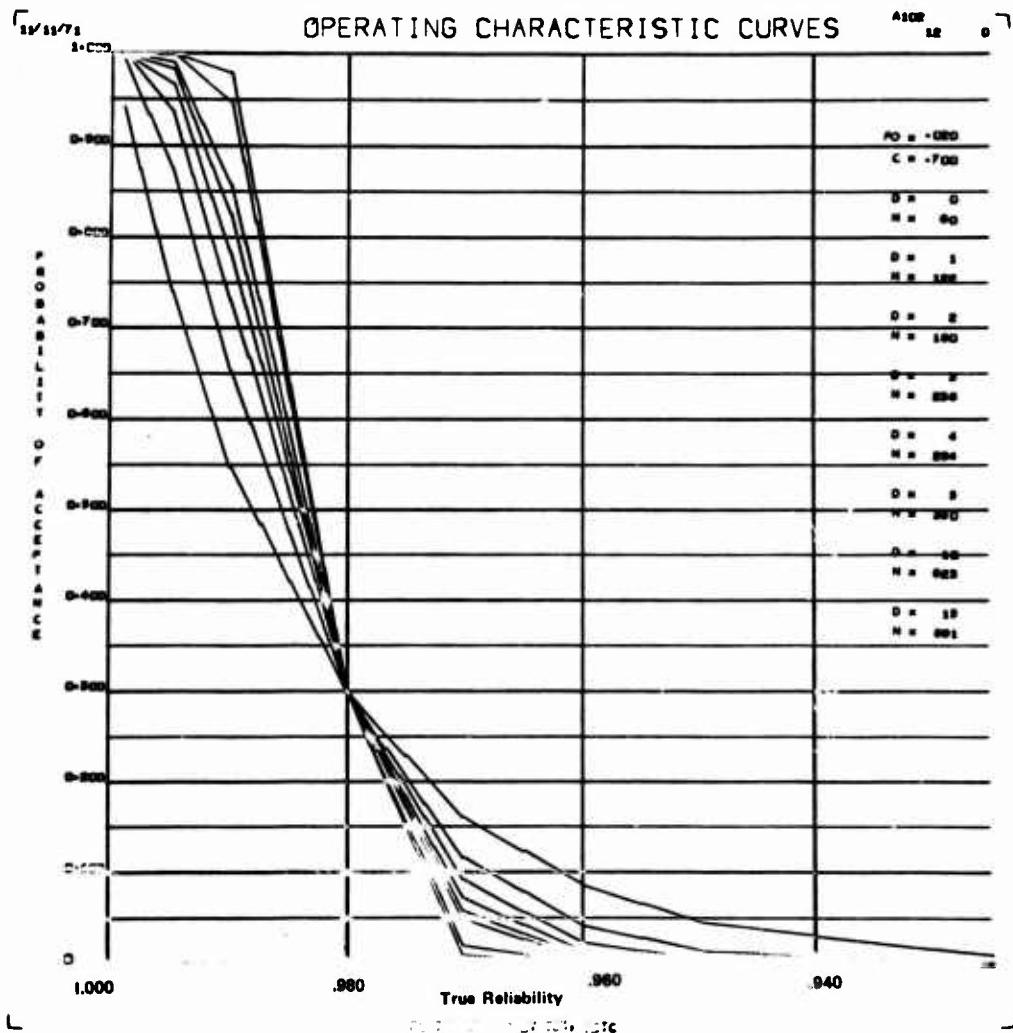
APPENDIX II

**OPERATING CHARACTERISTIC
CURVES ($p_0 = .020$)**



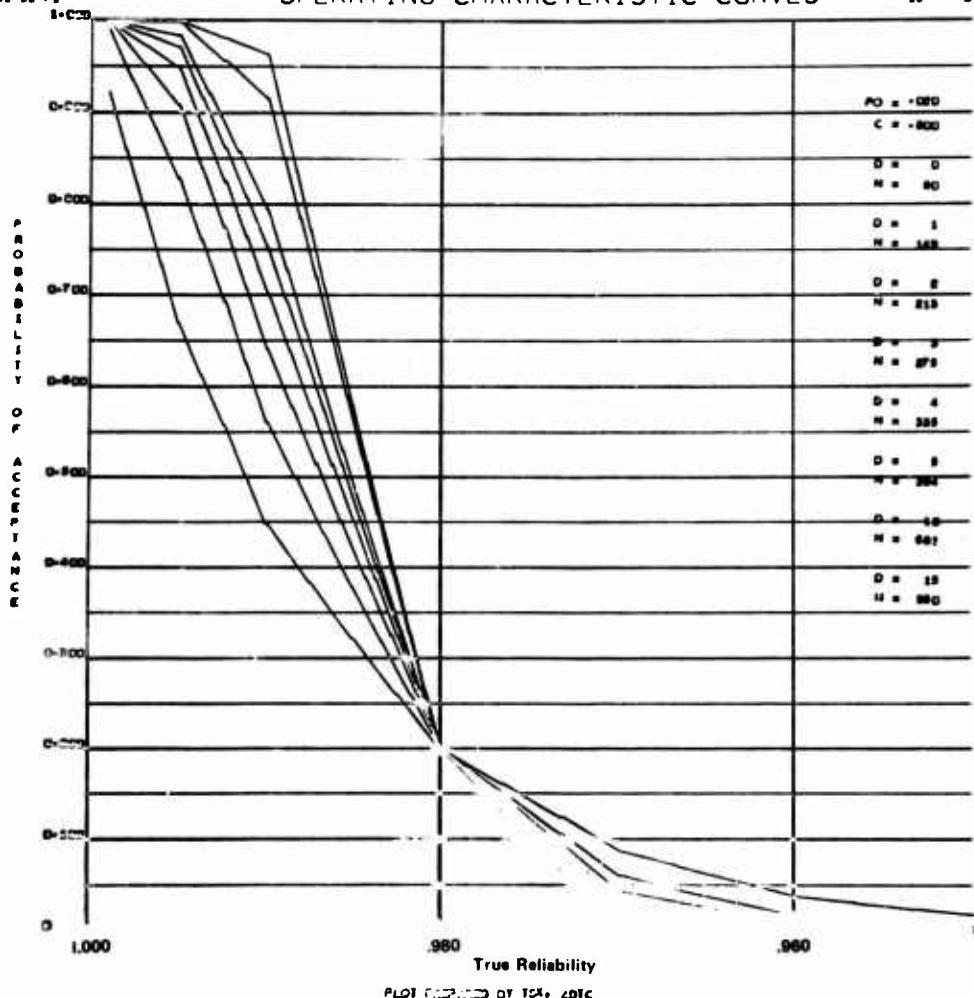
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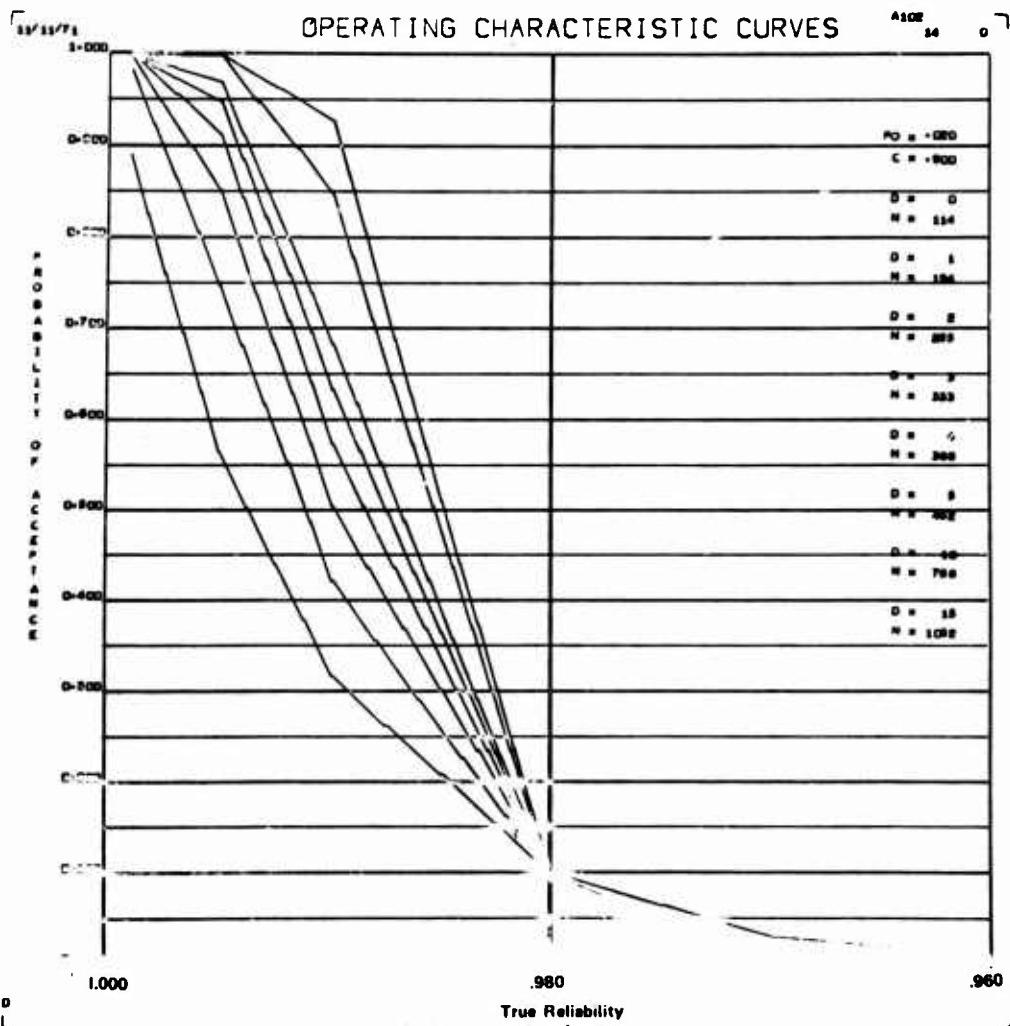




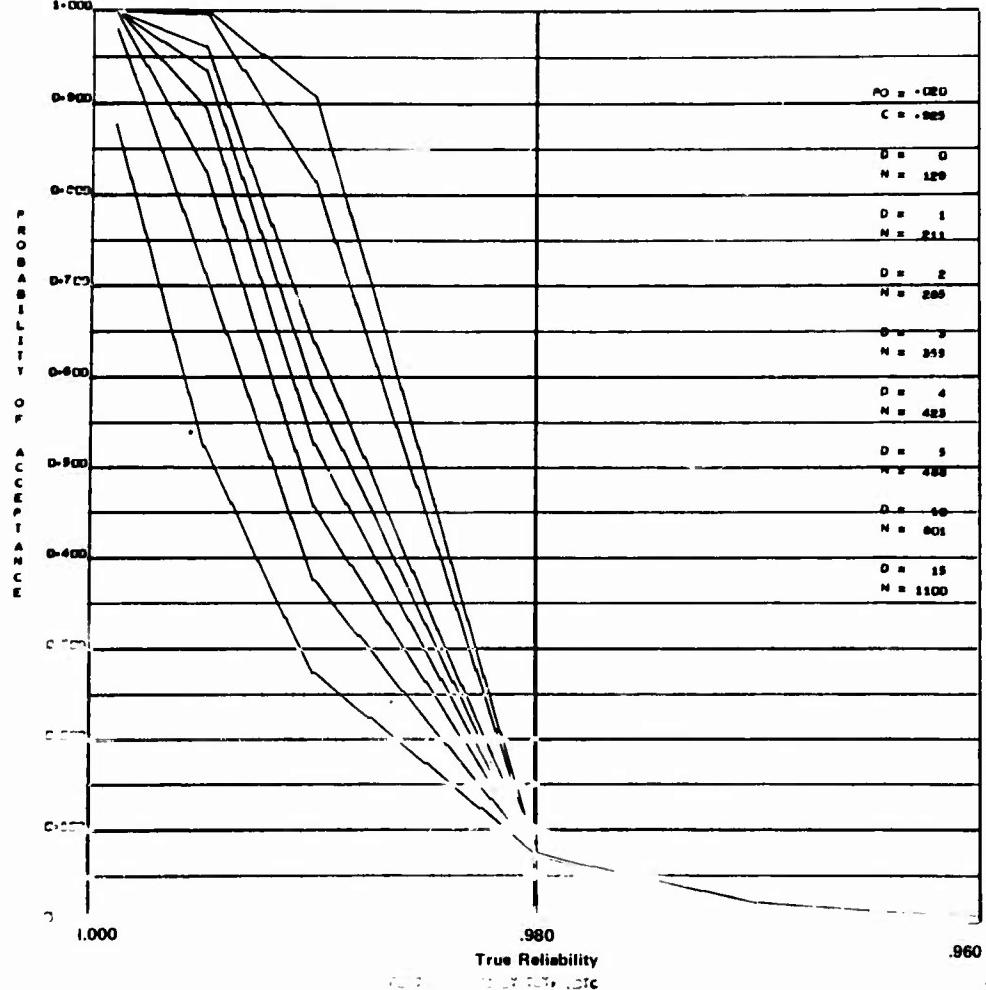
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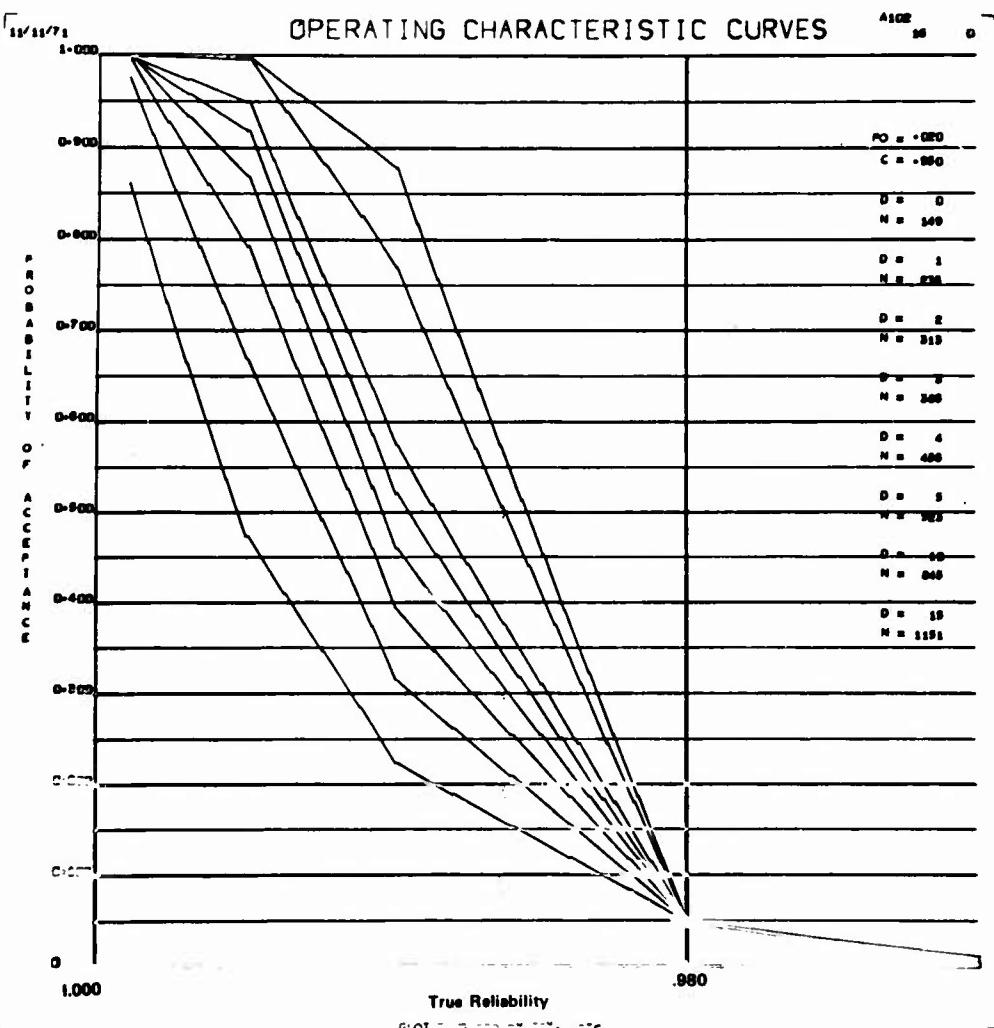
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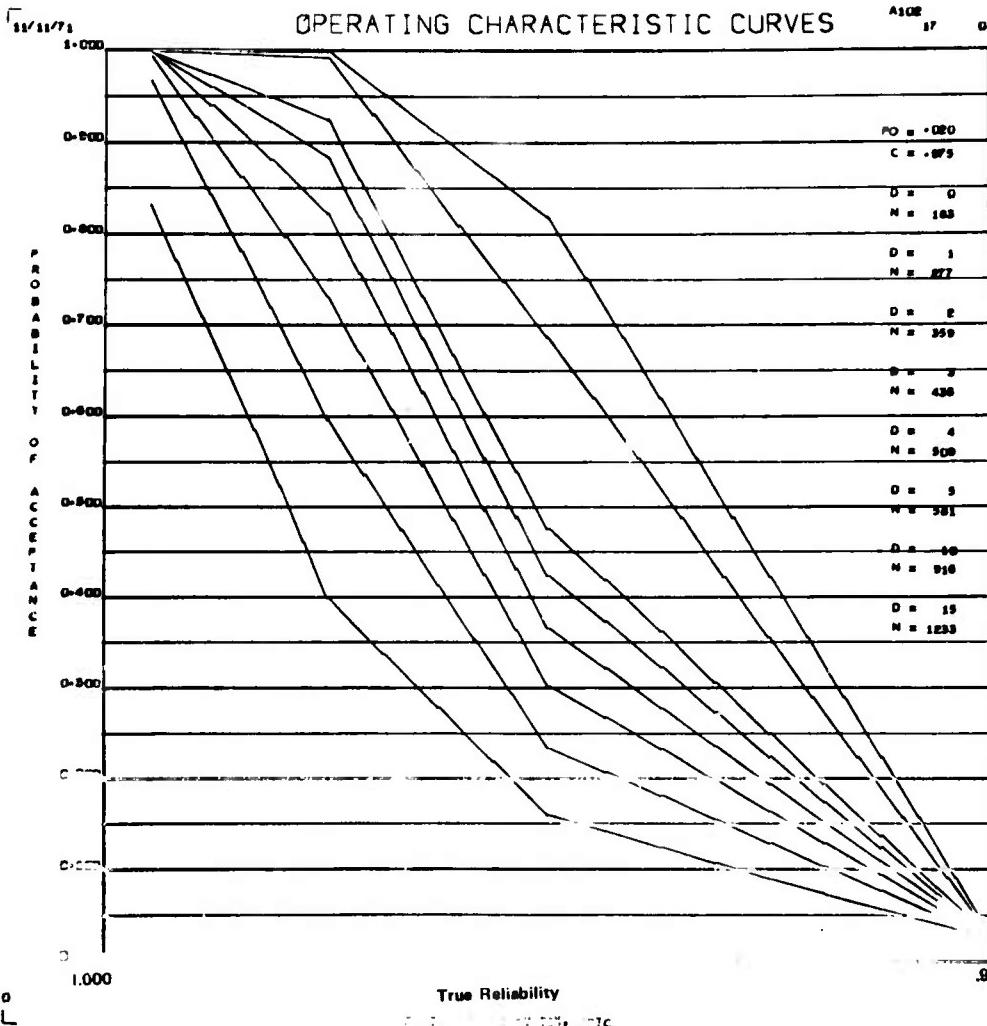


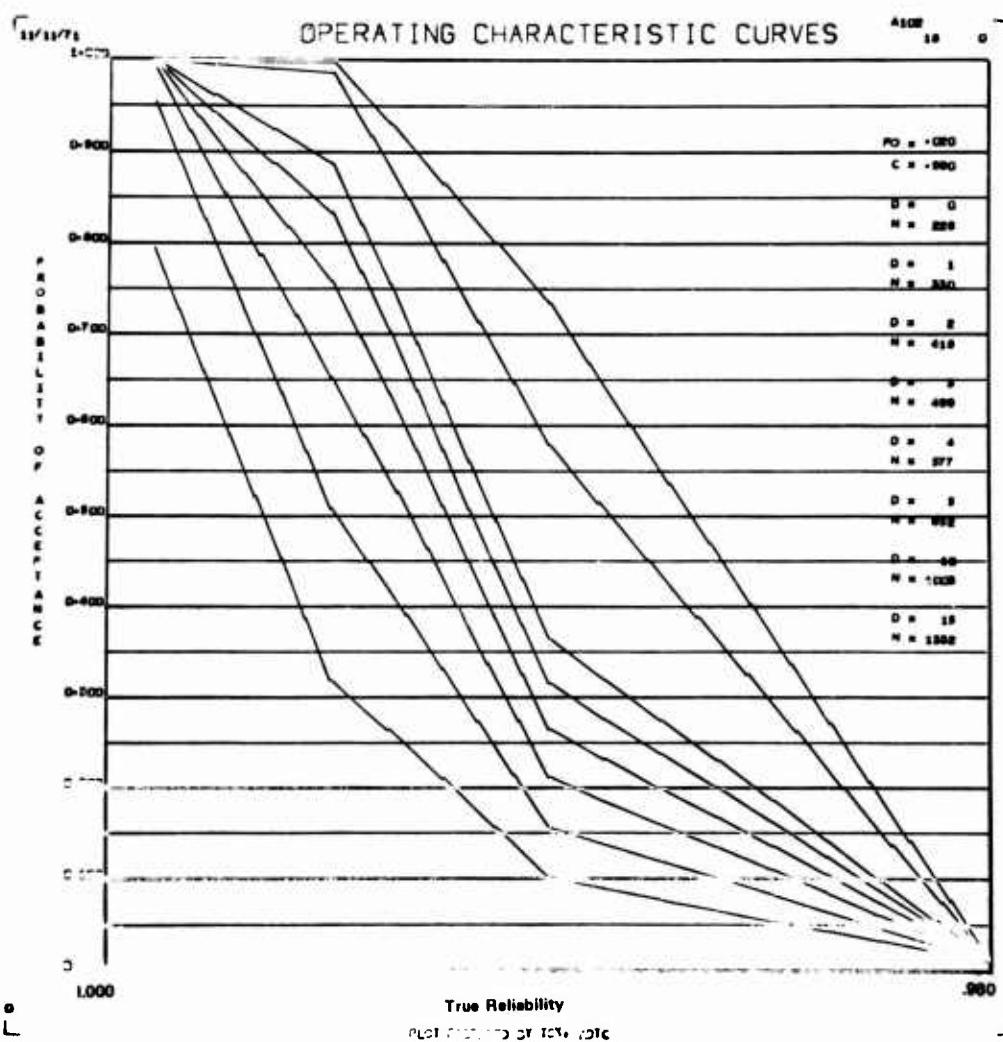


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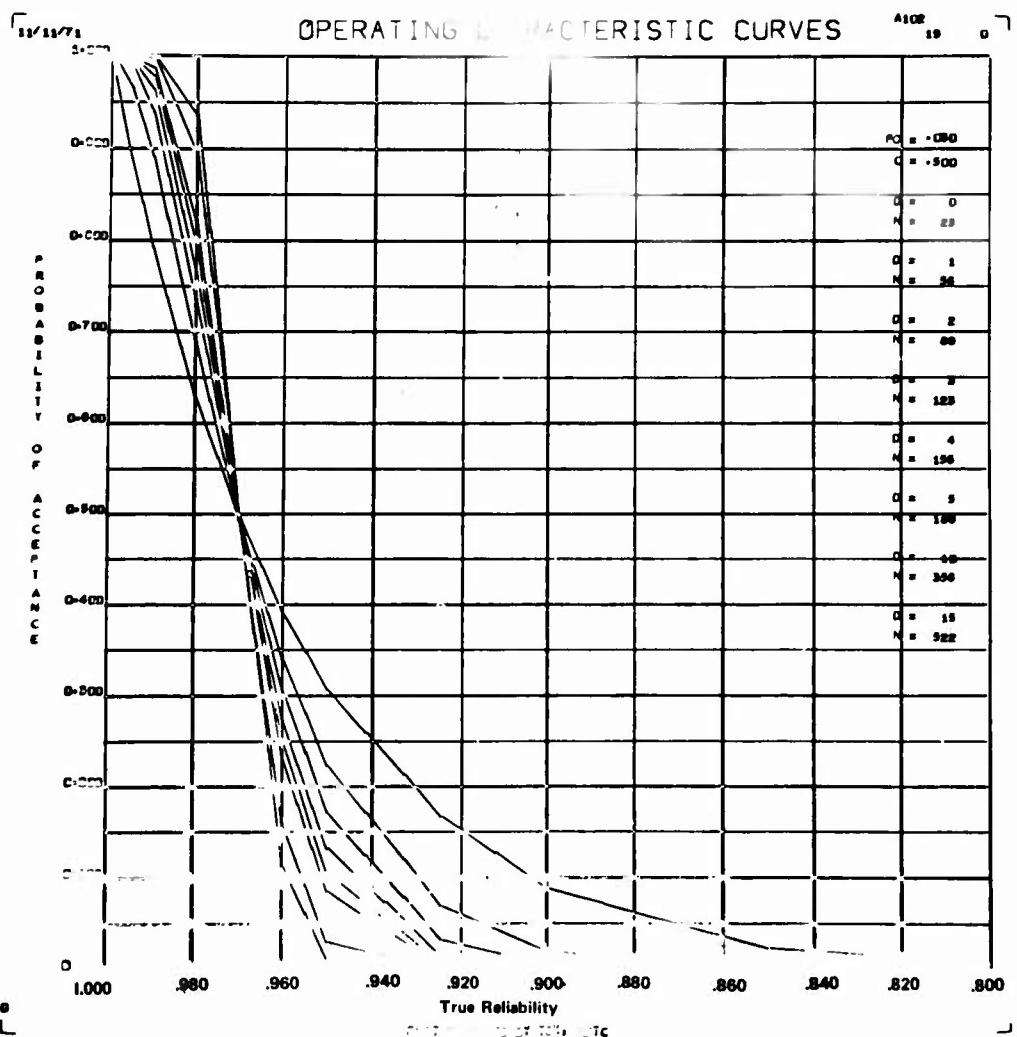


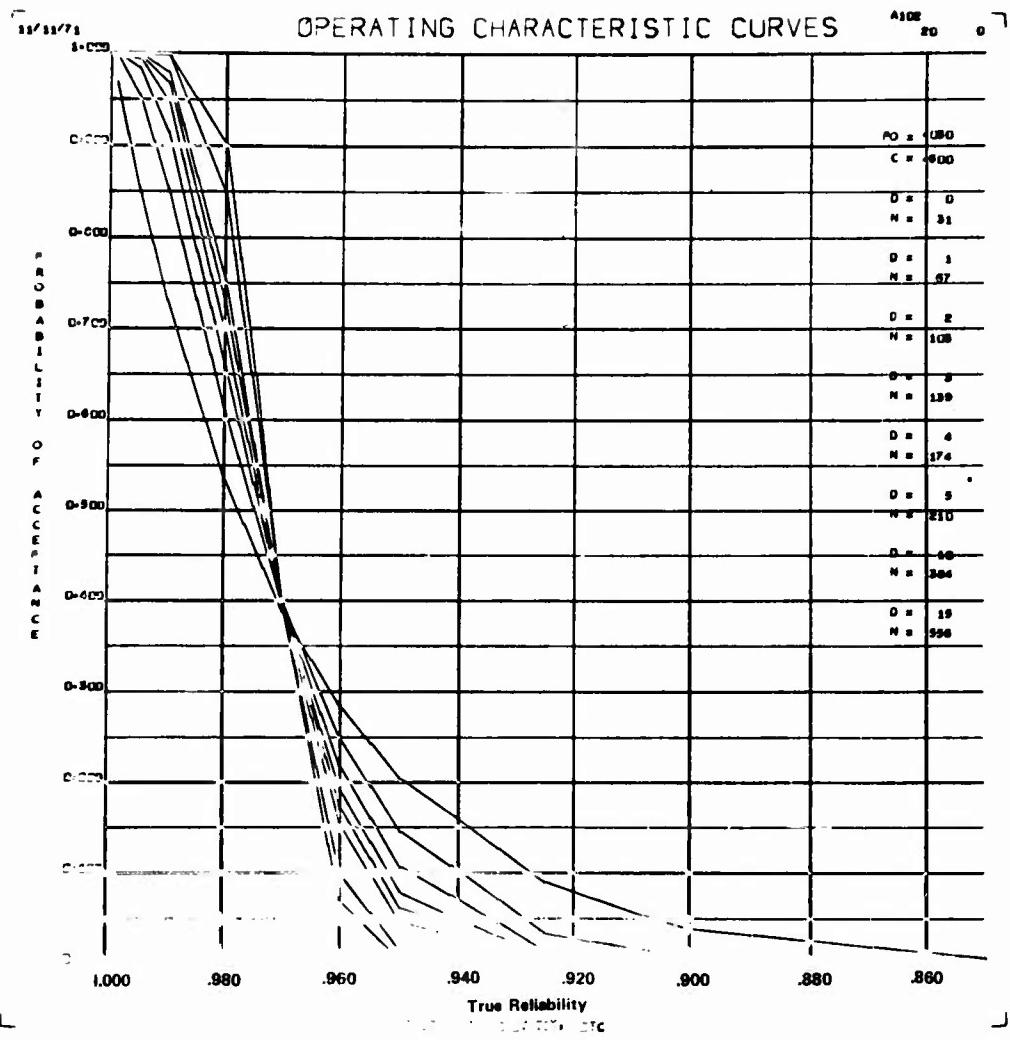


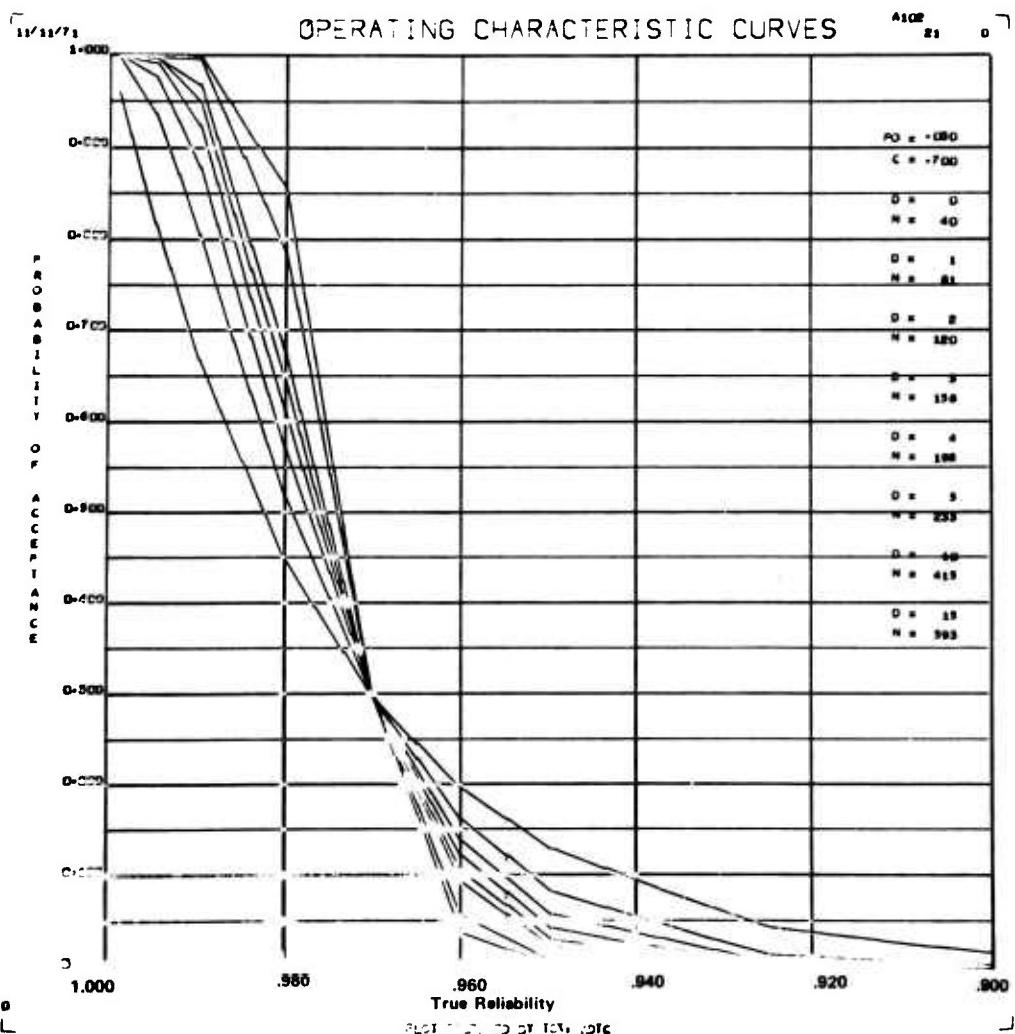




APPENDIX III
OPERATING CHARACTERISTIC
CURVES ($p_0 = .030$)



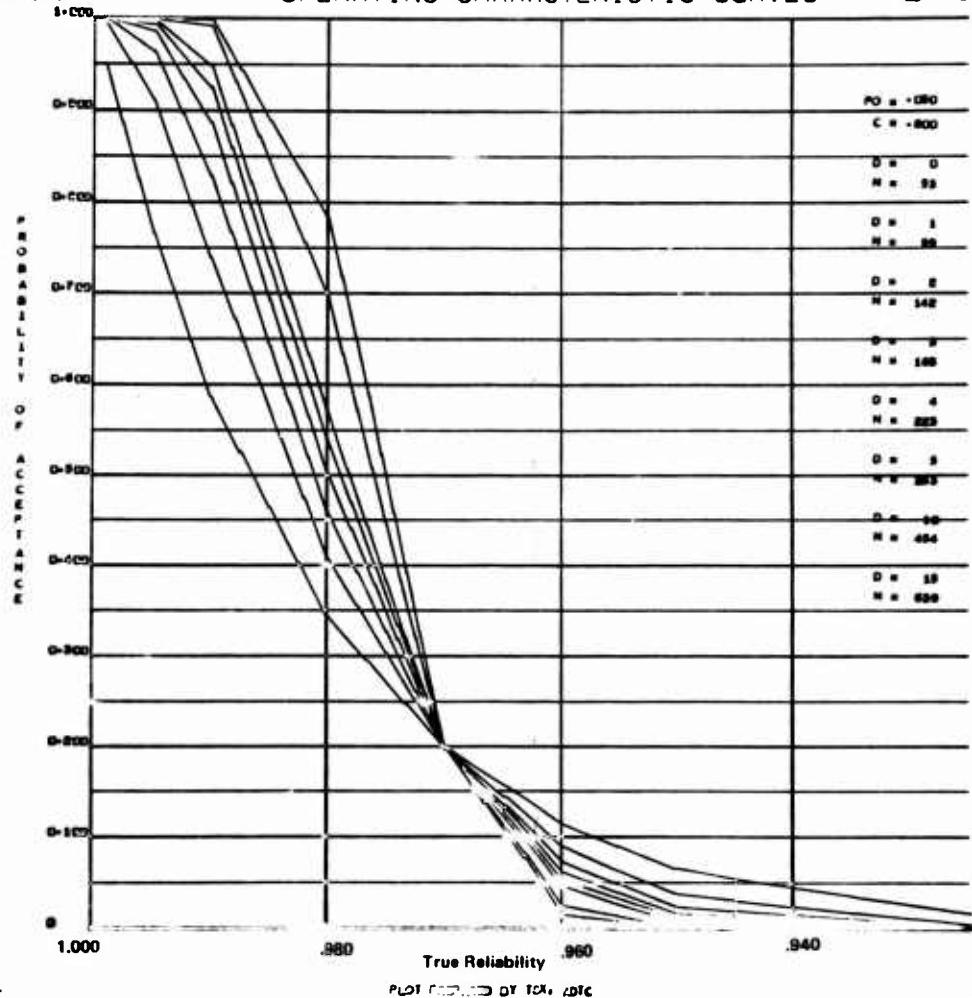


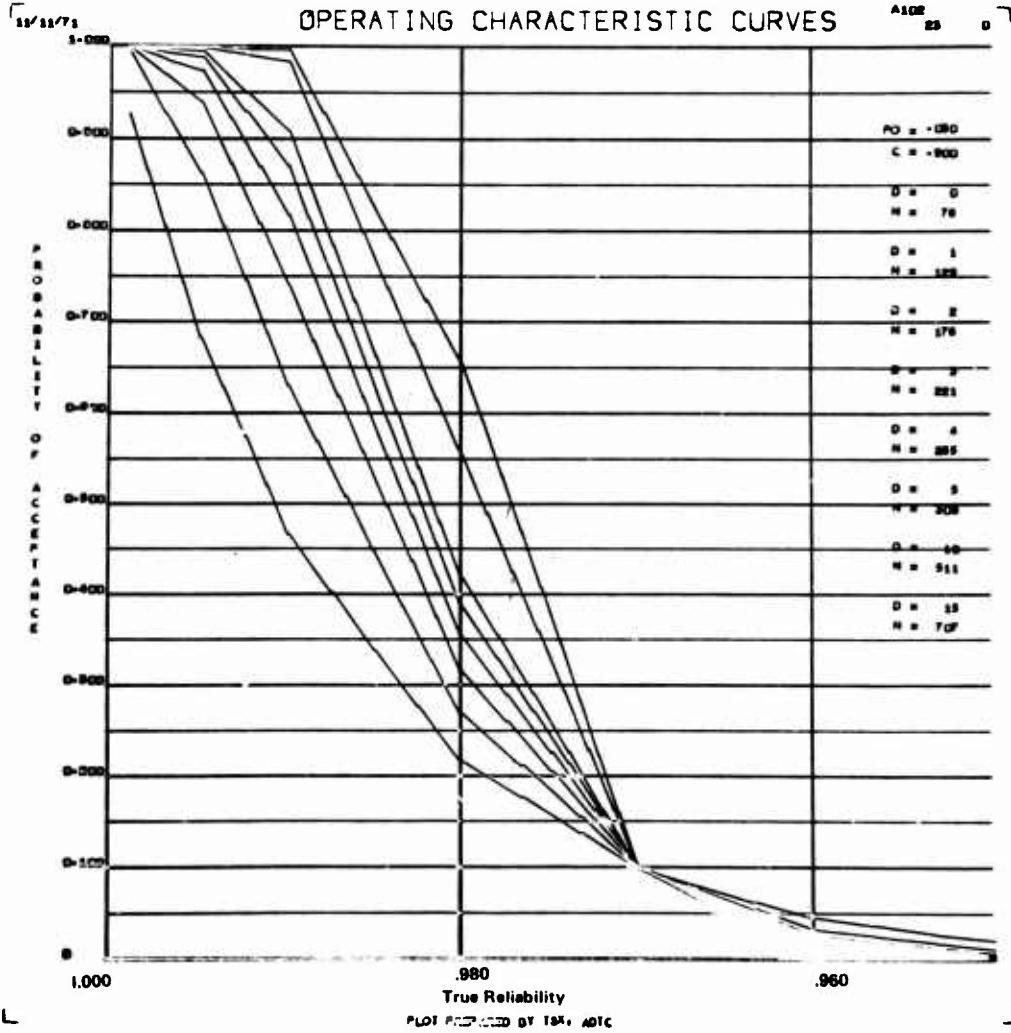


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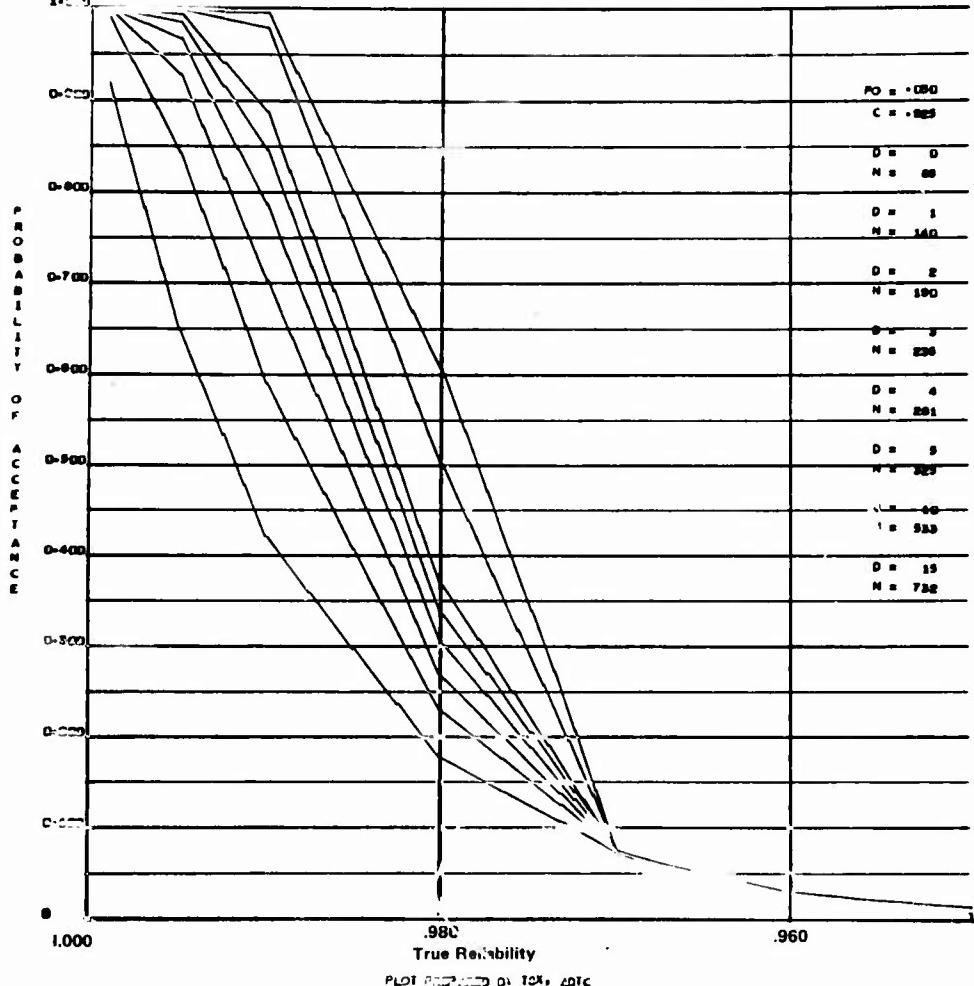




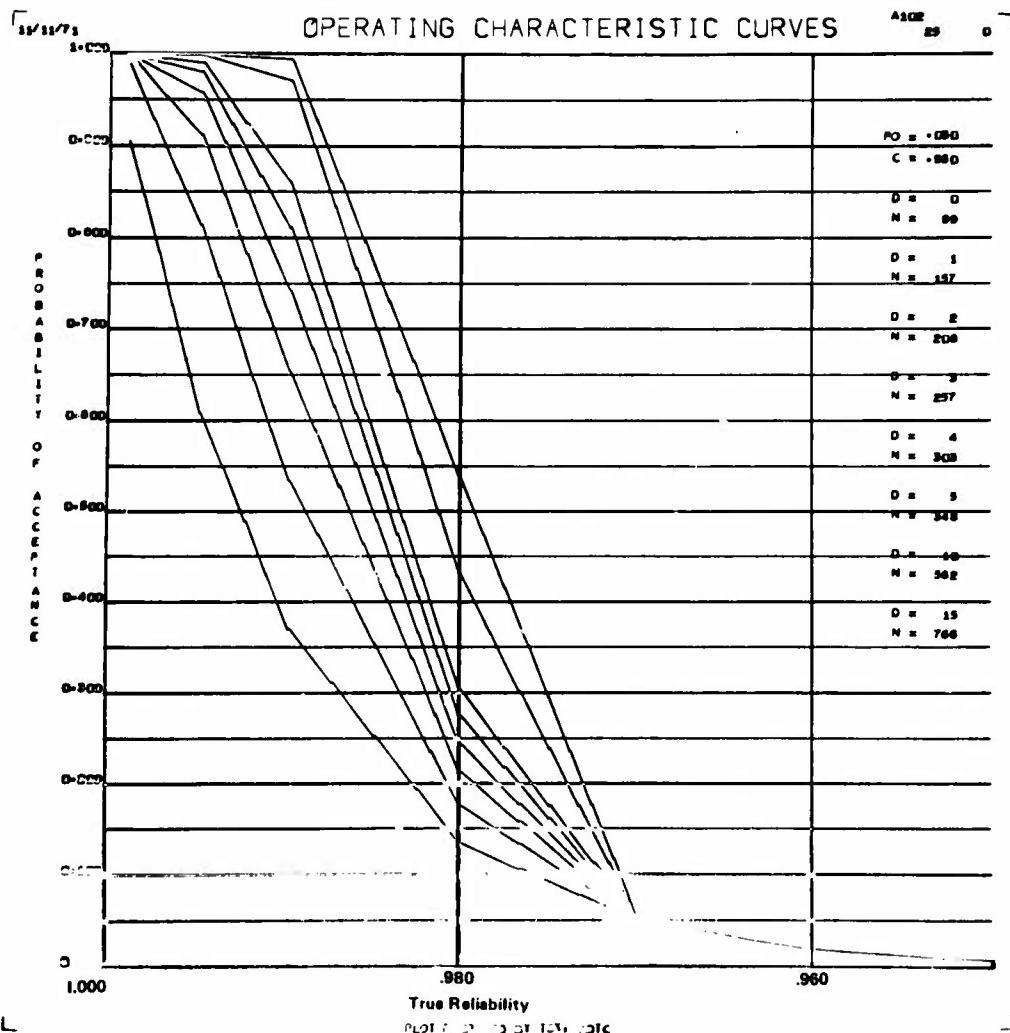
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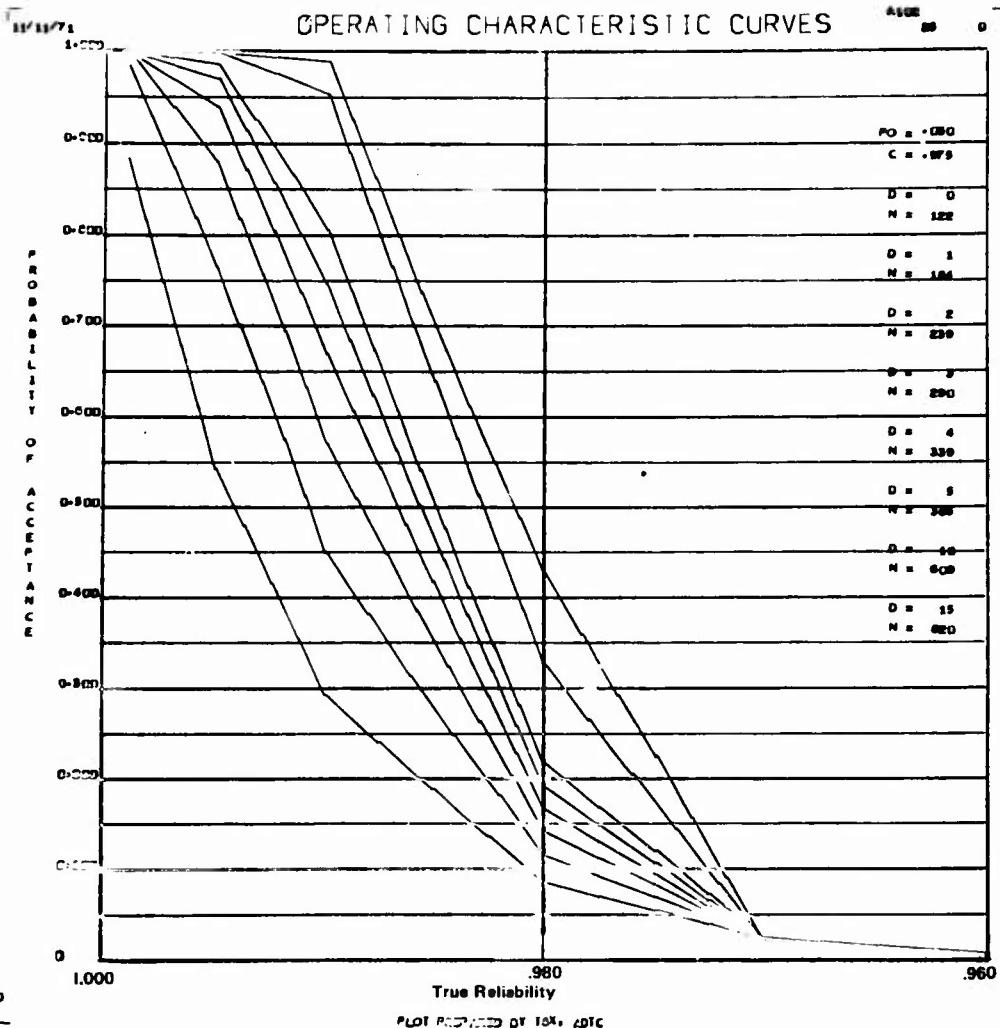
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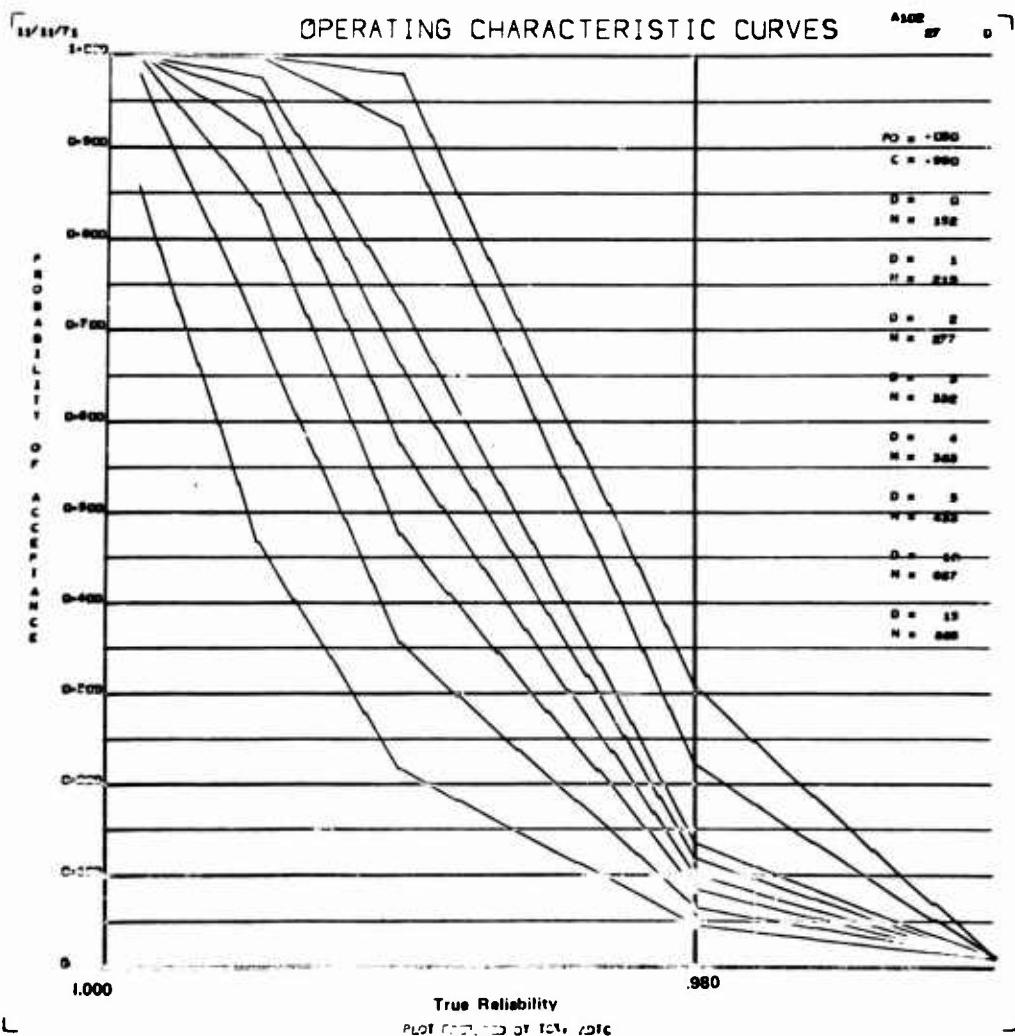
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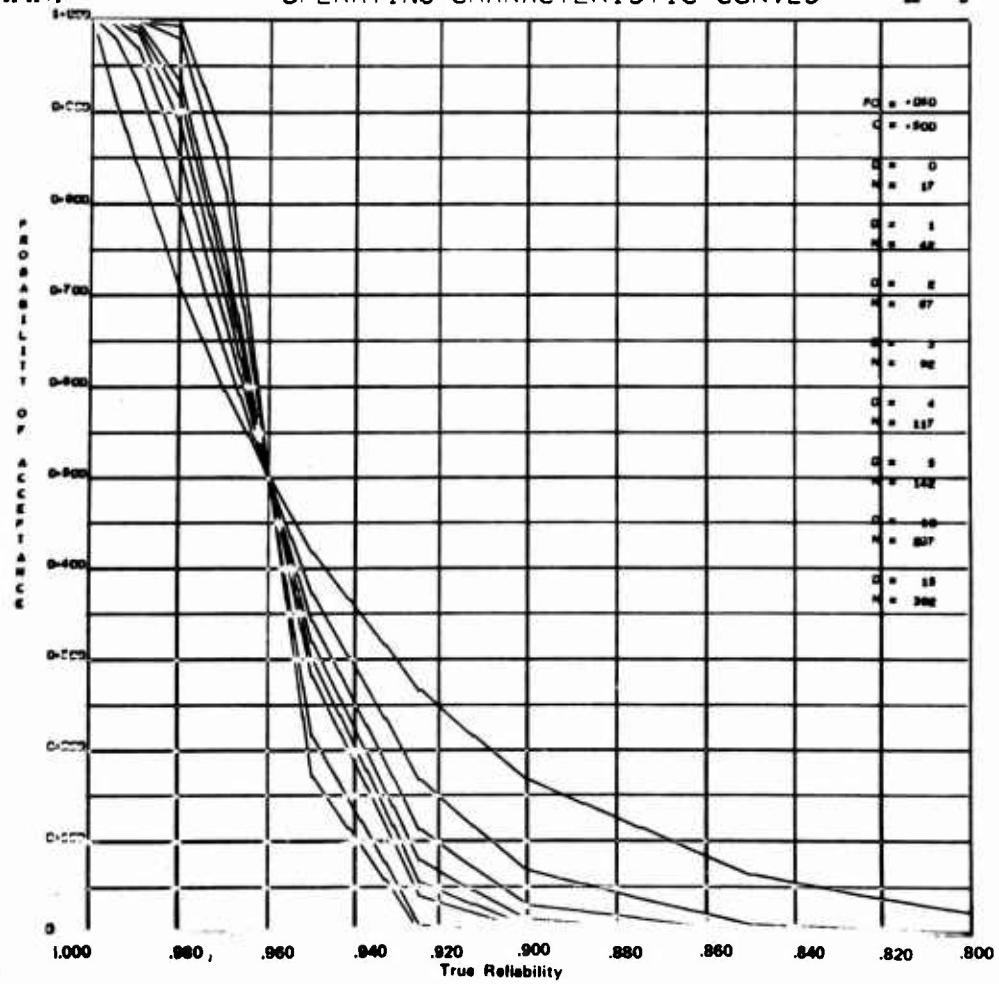


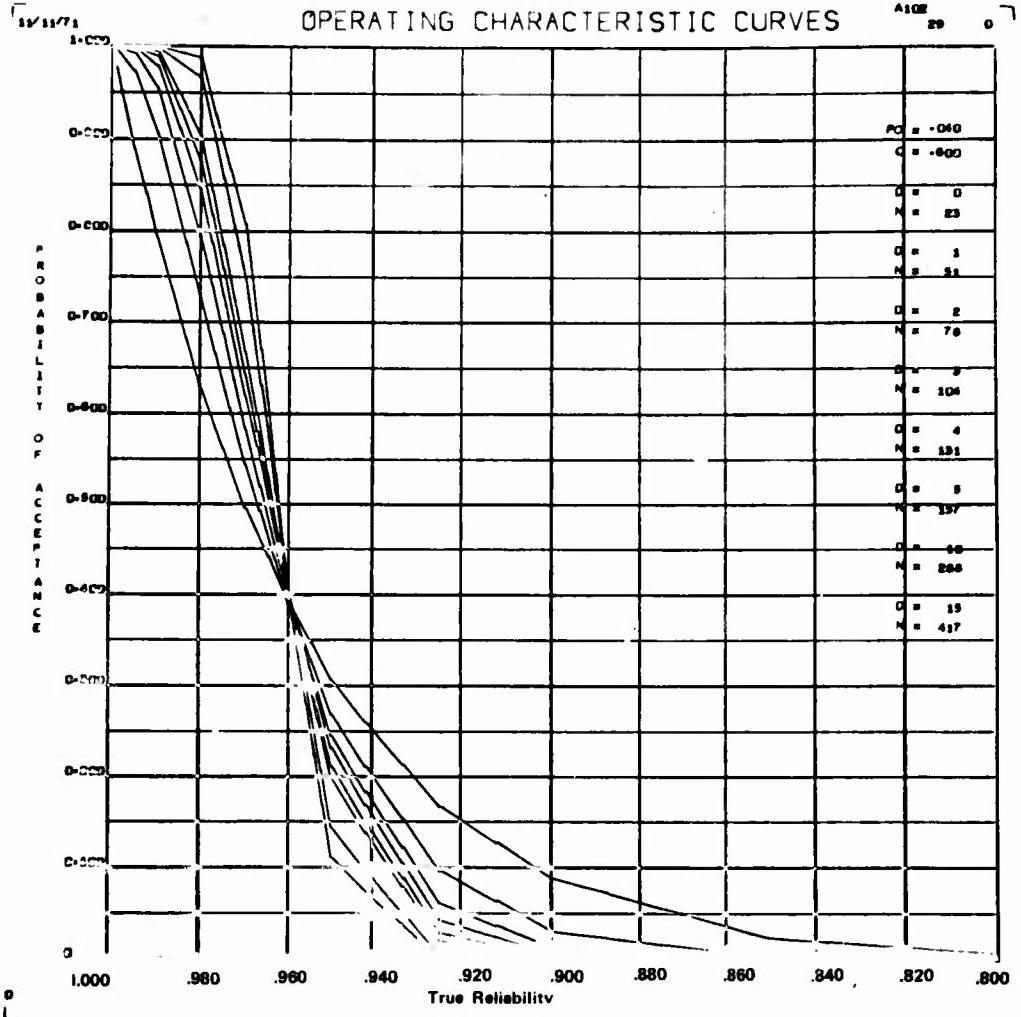


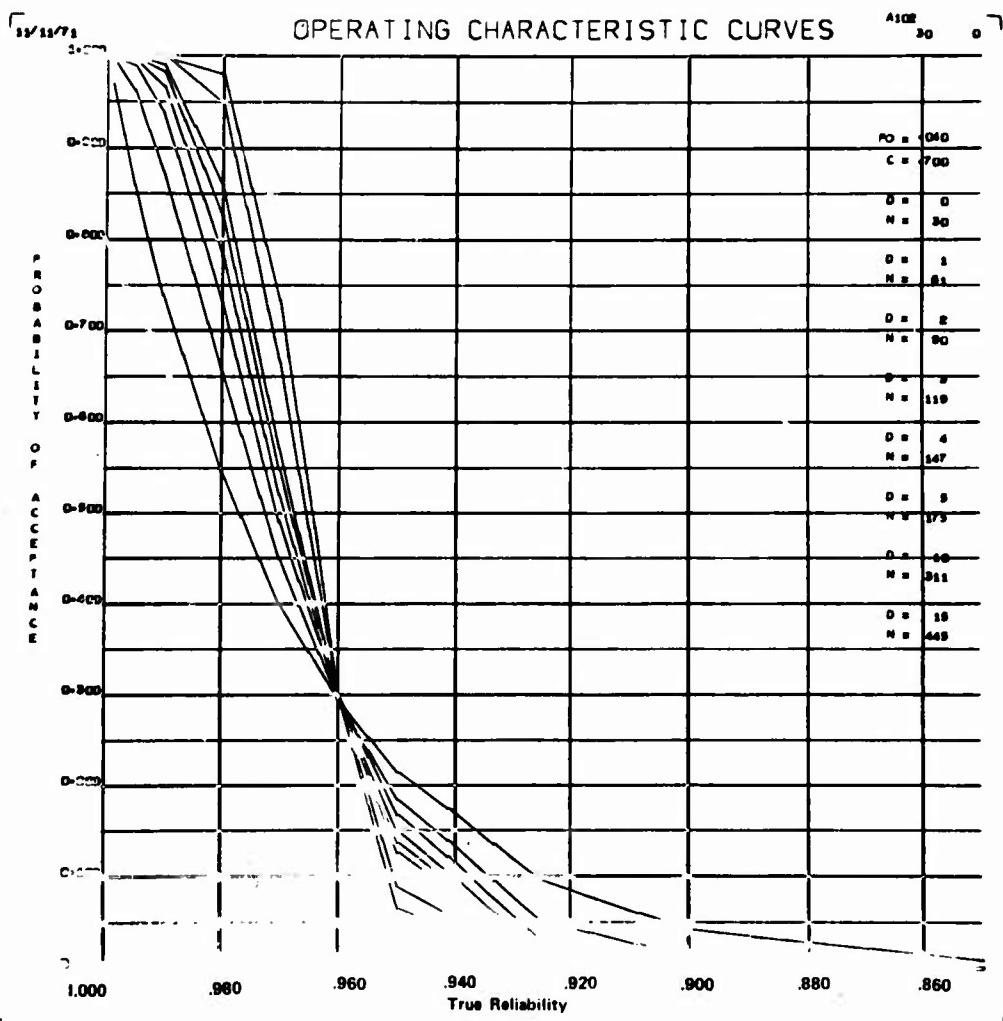


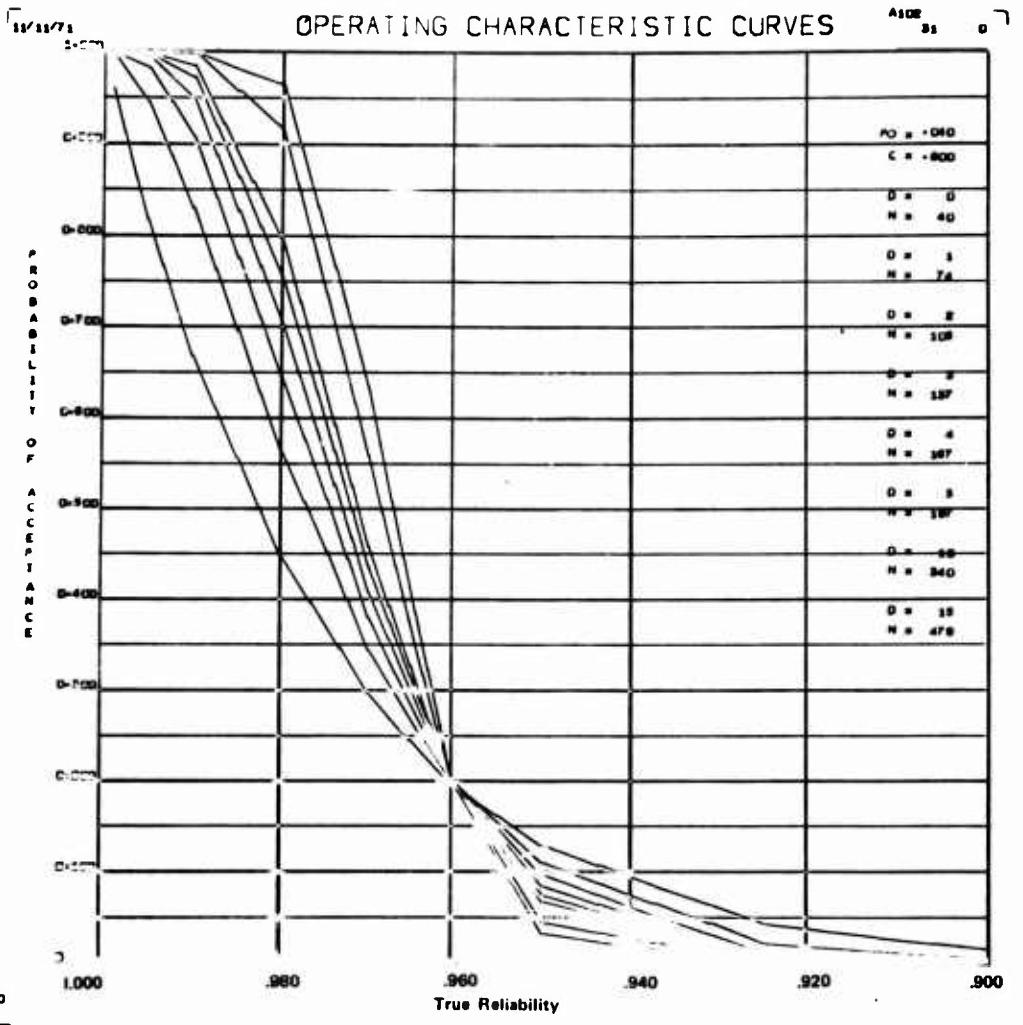
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CURVES ($p_0 = .040$)

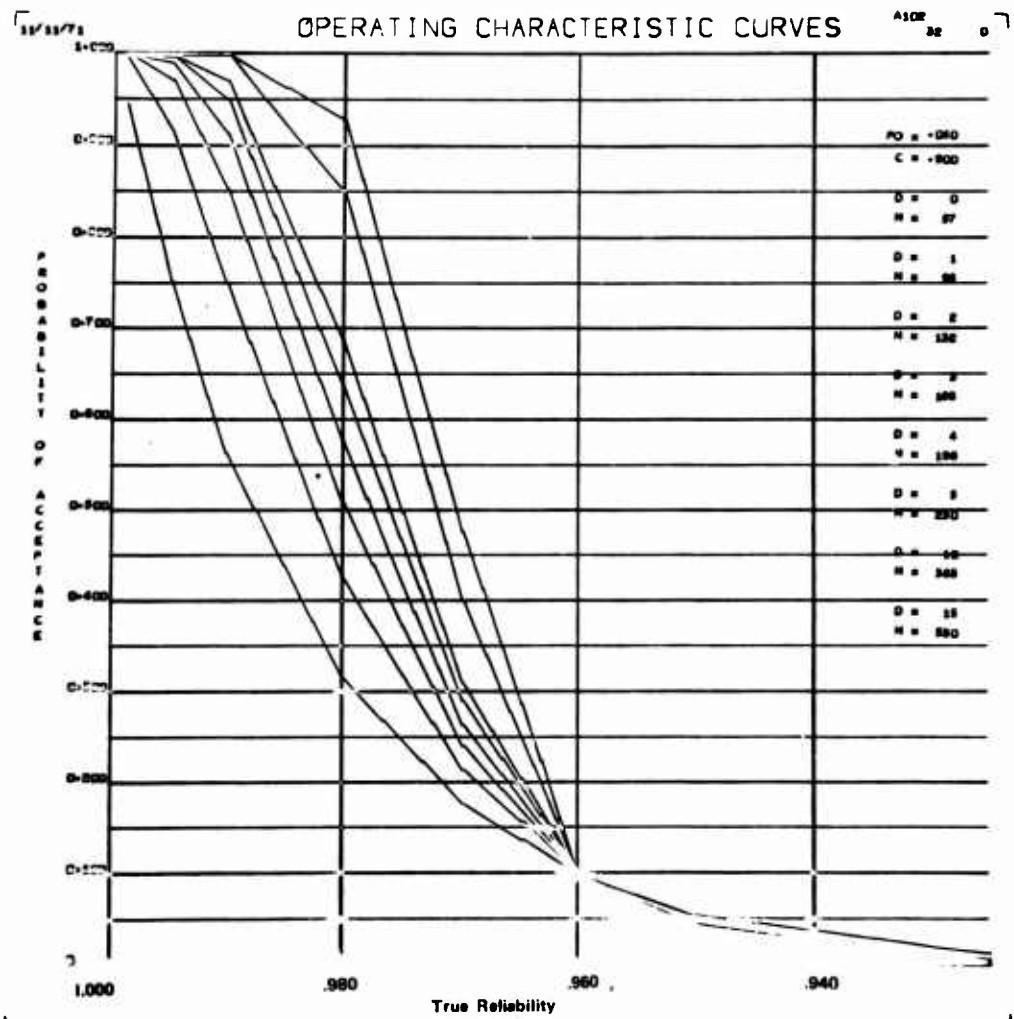
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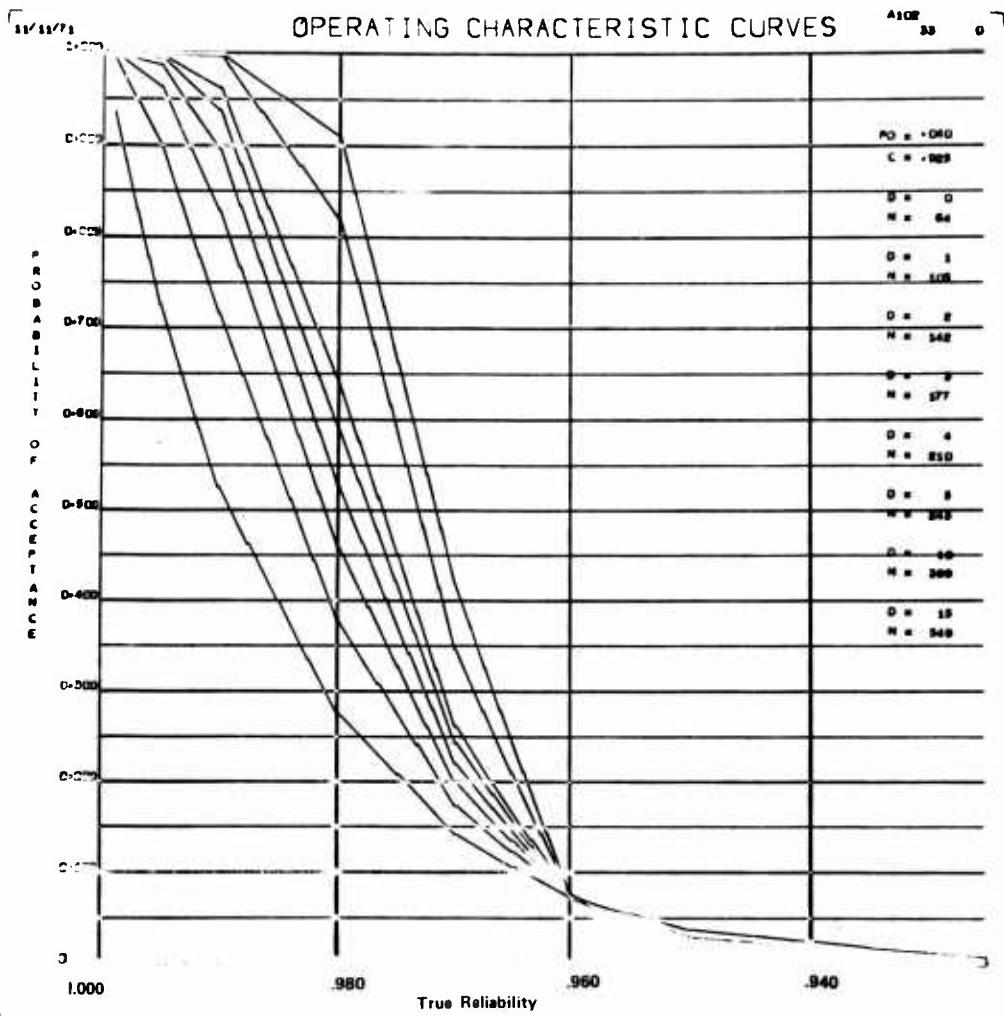


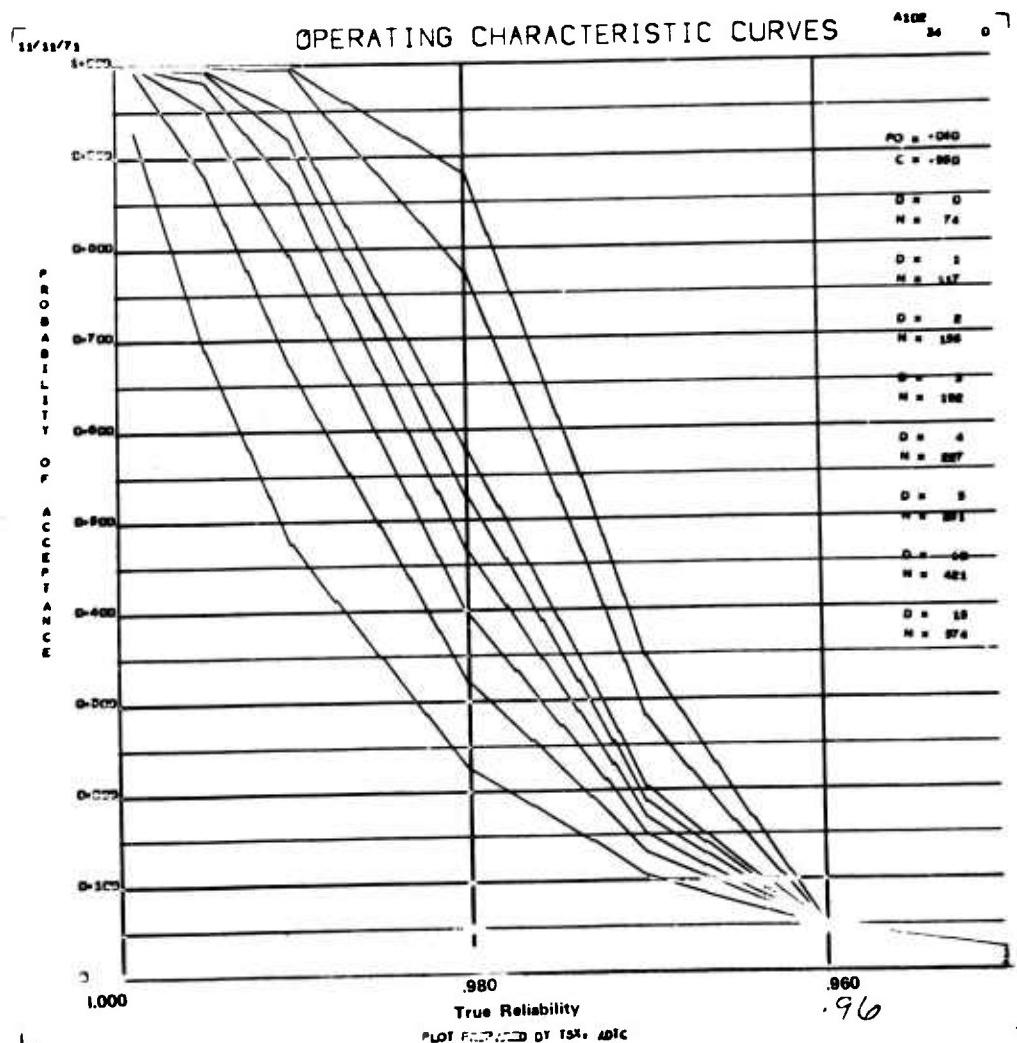


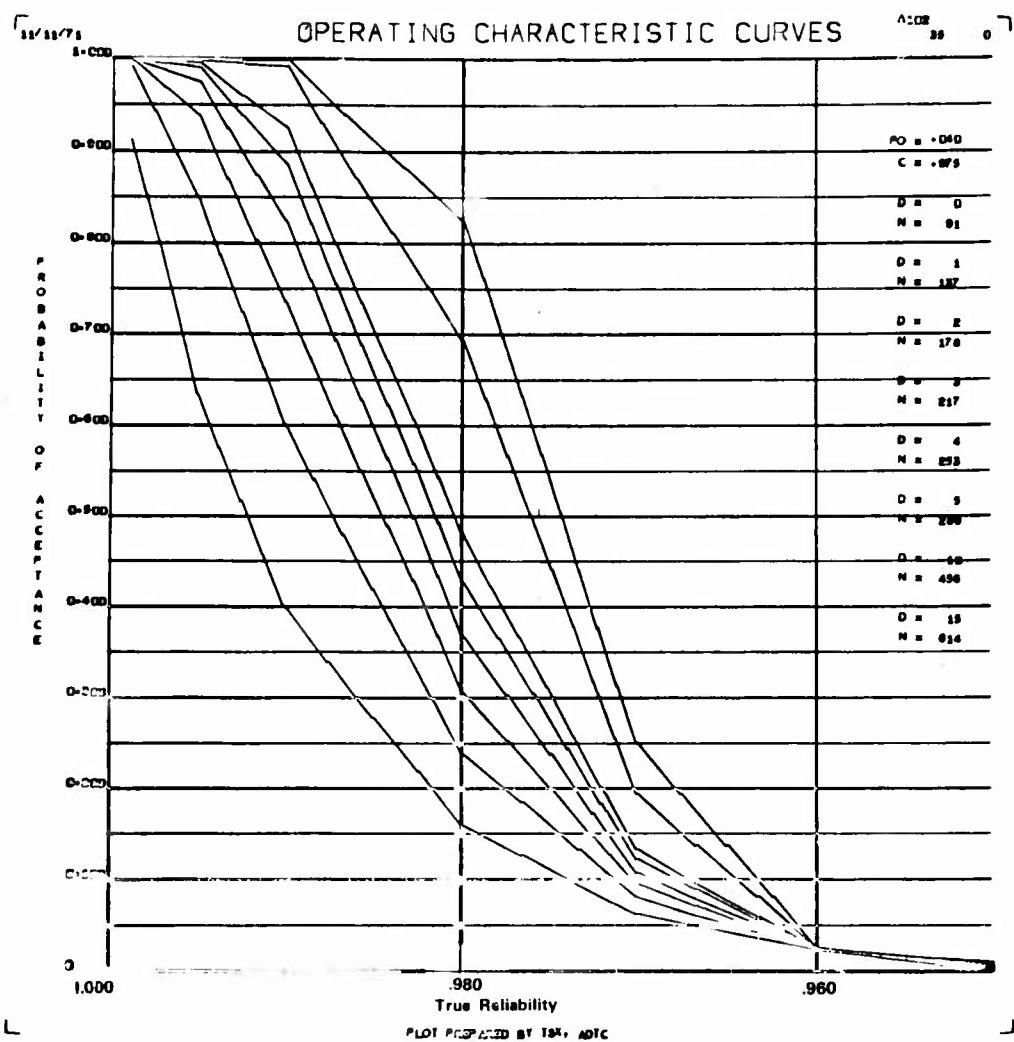


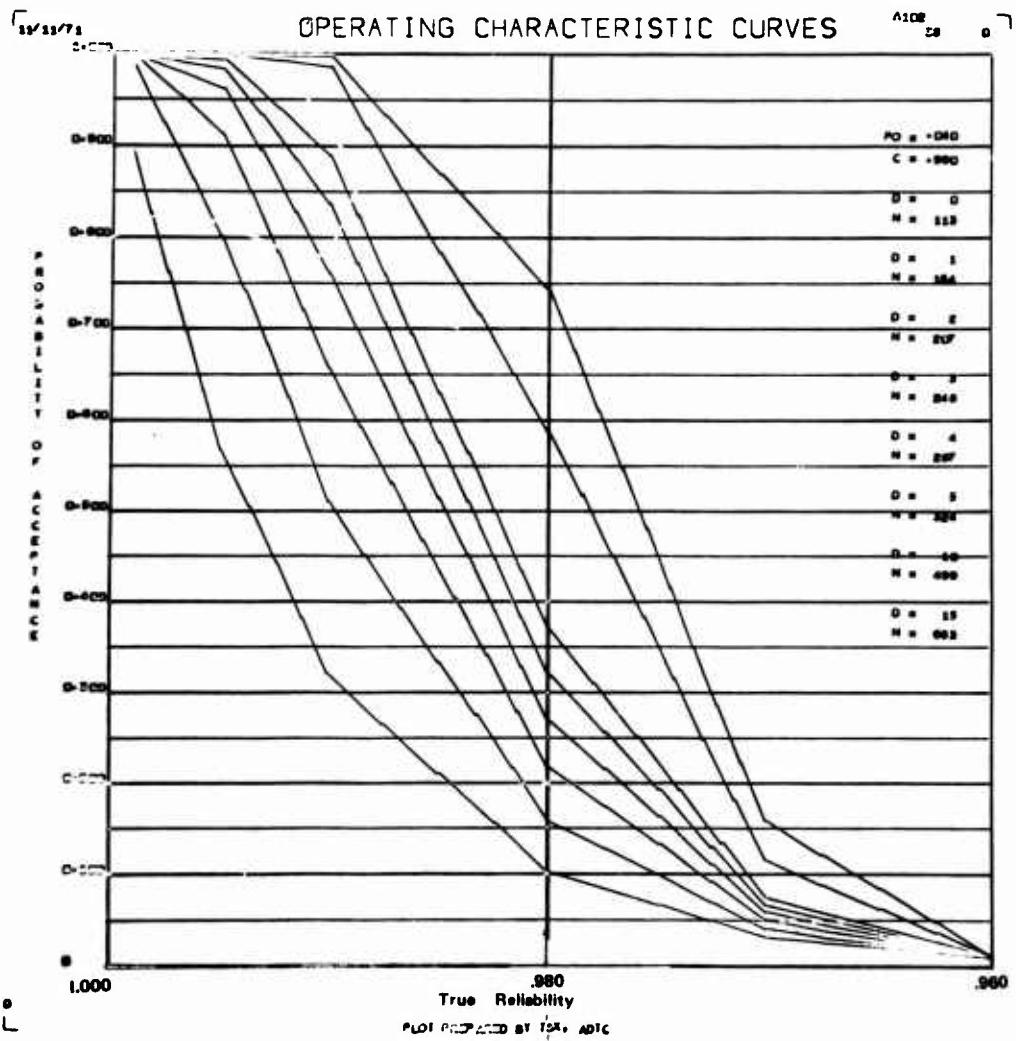










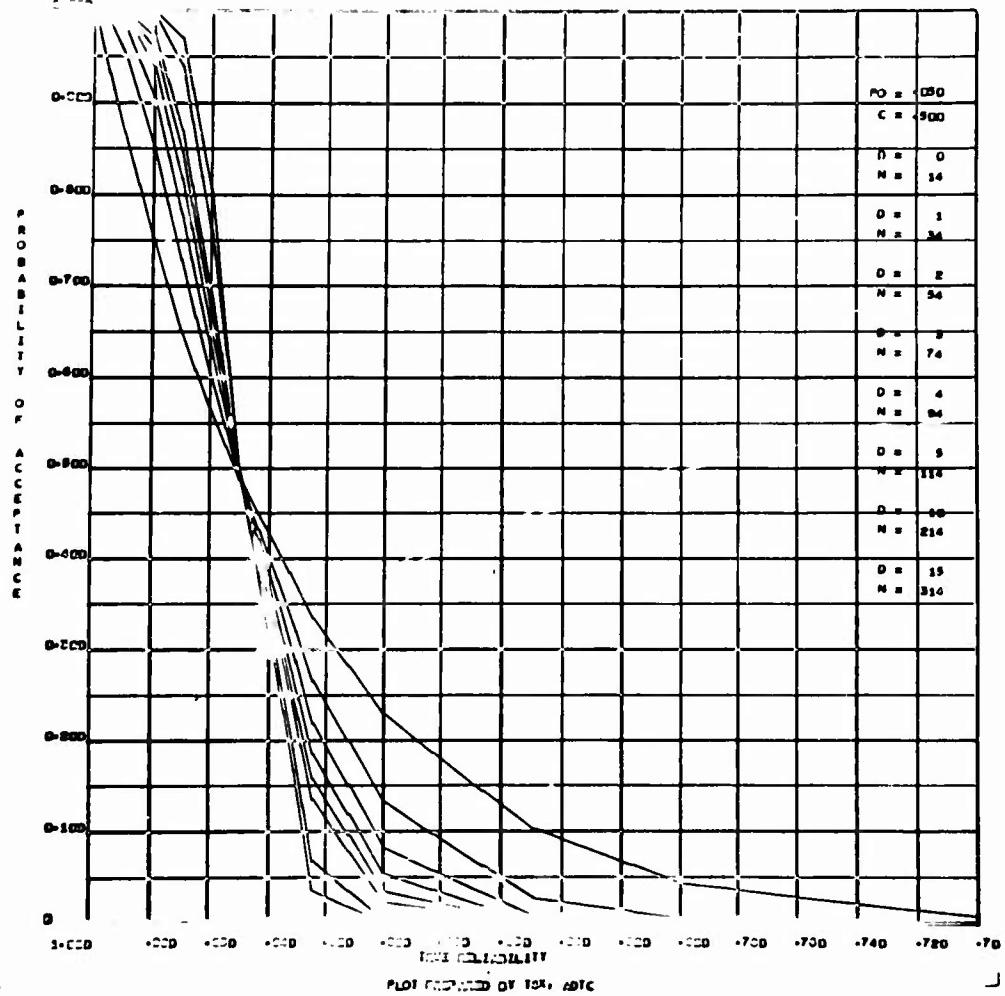


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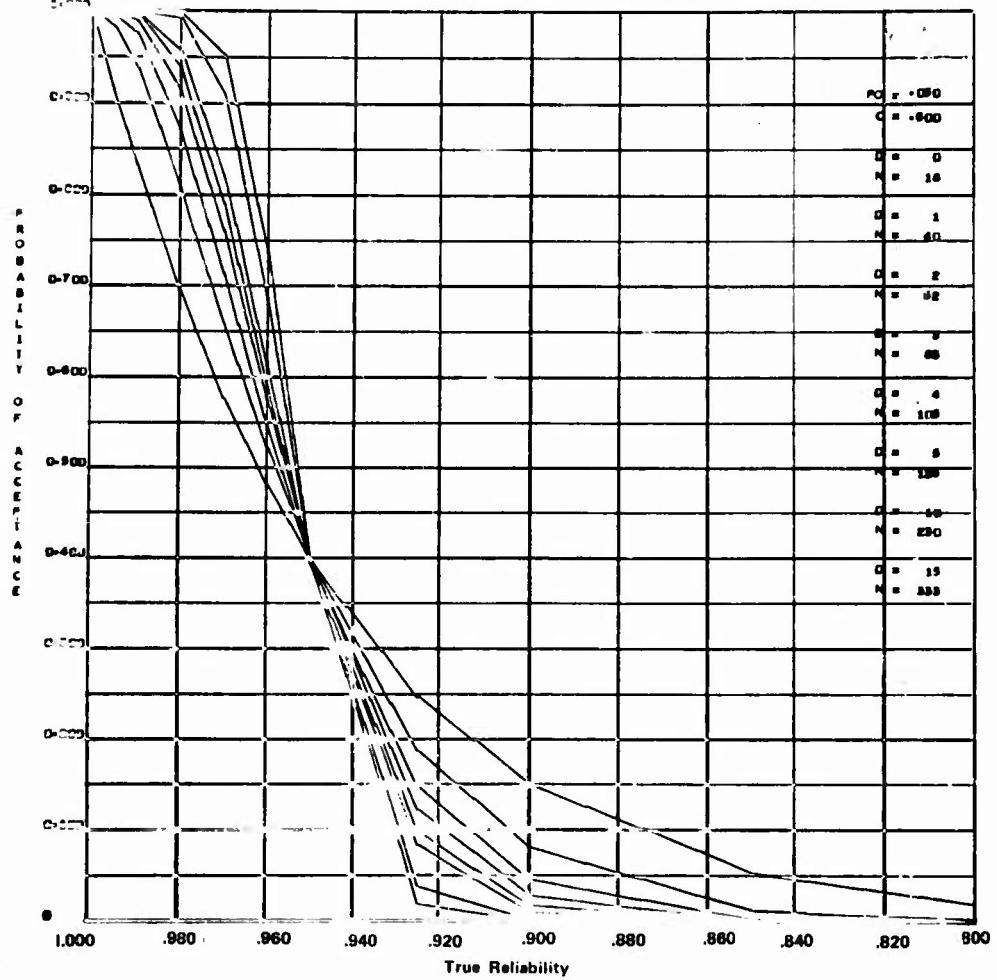
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CURVES ($p_0 = .050$)**

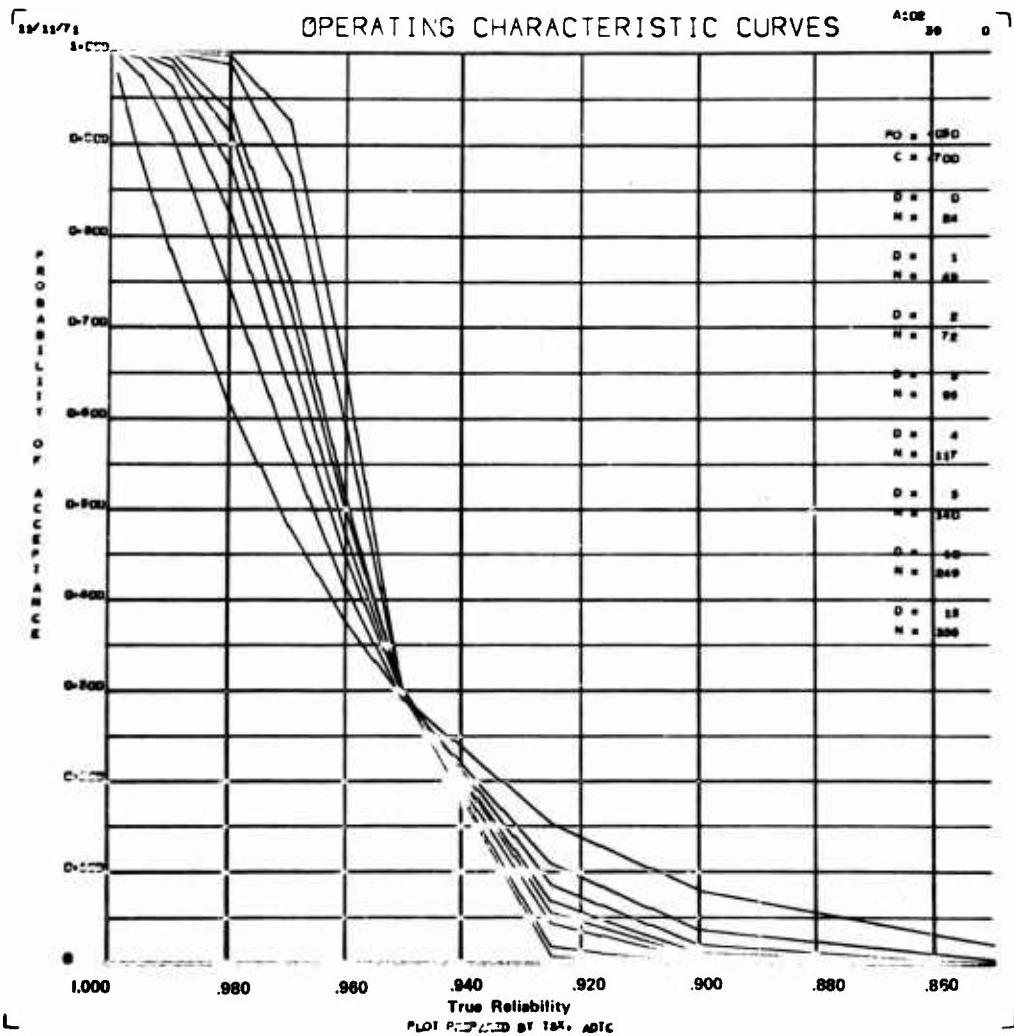
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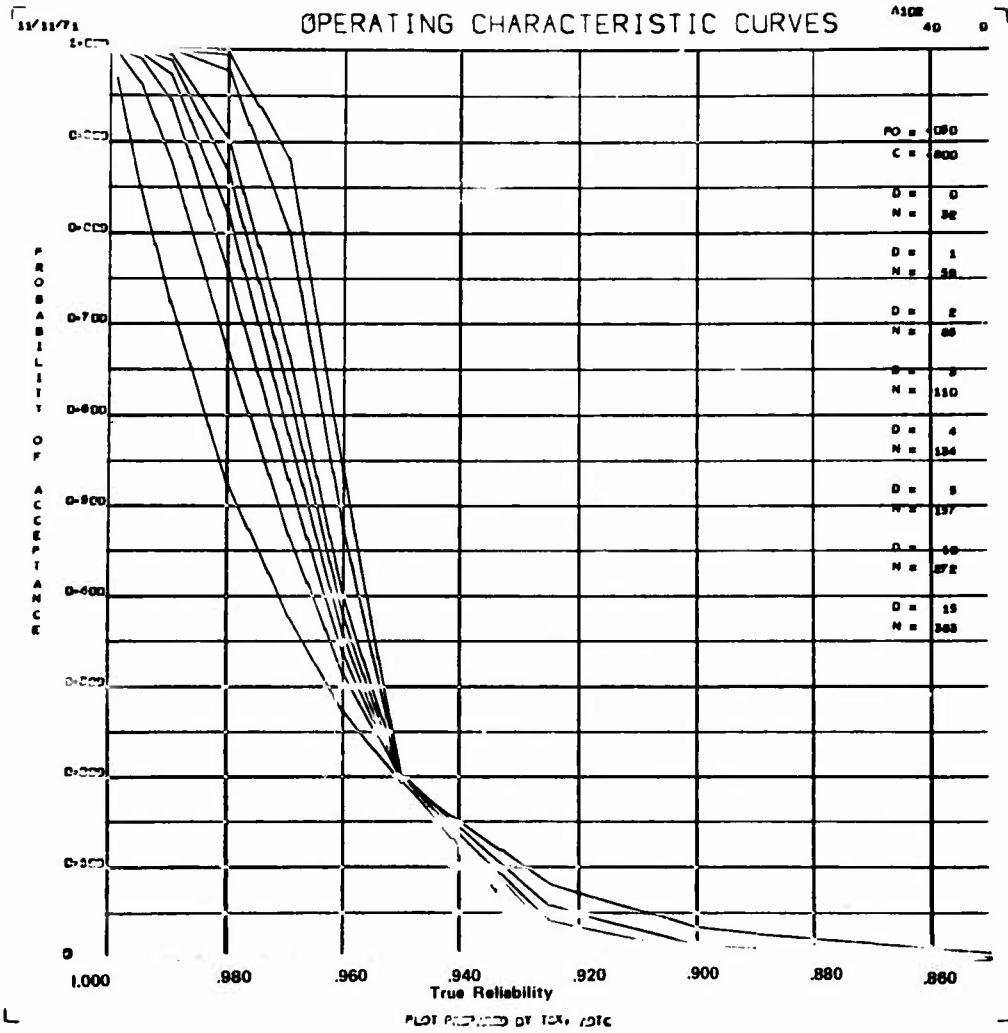
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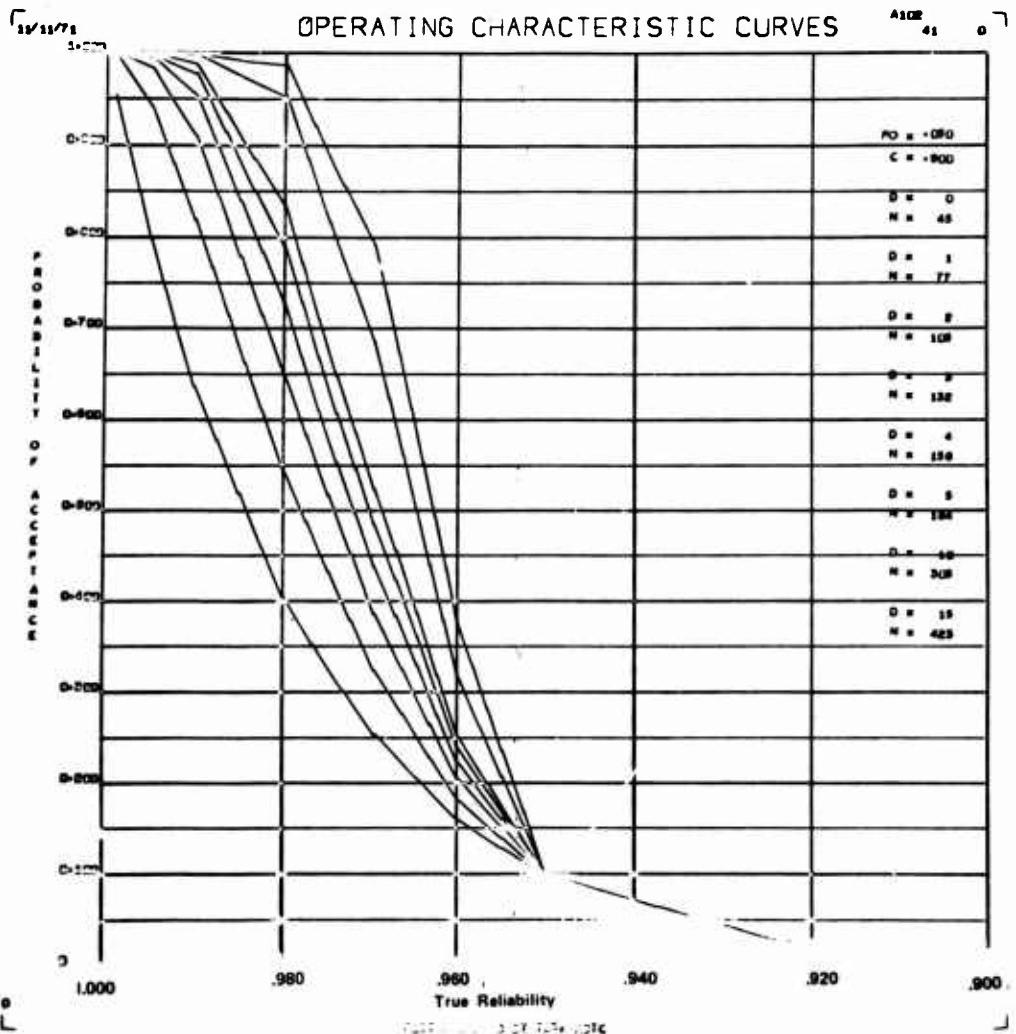


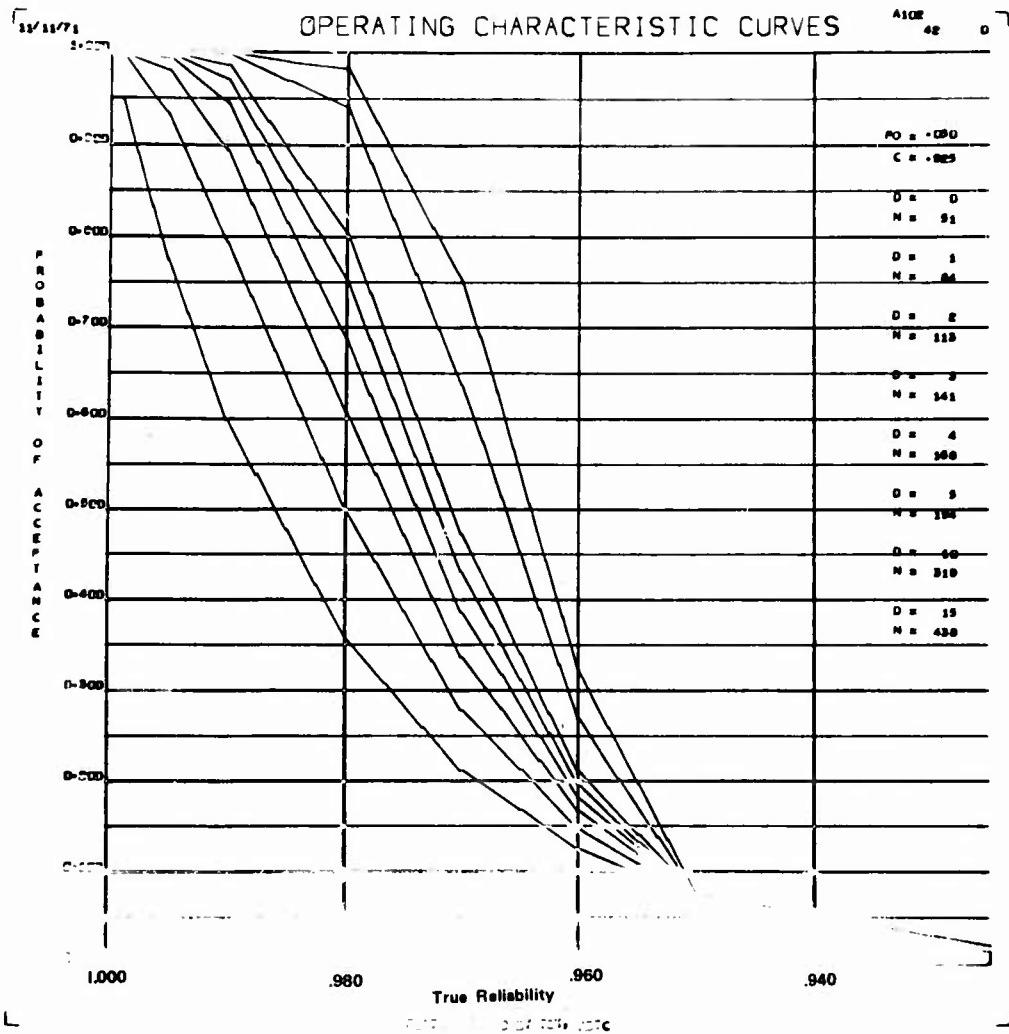
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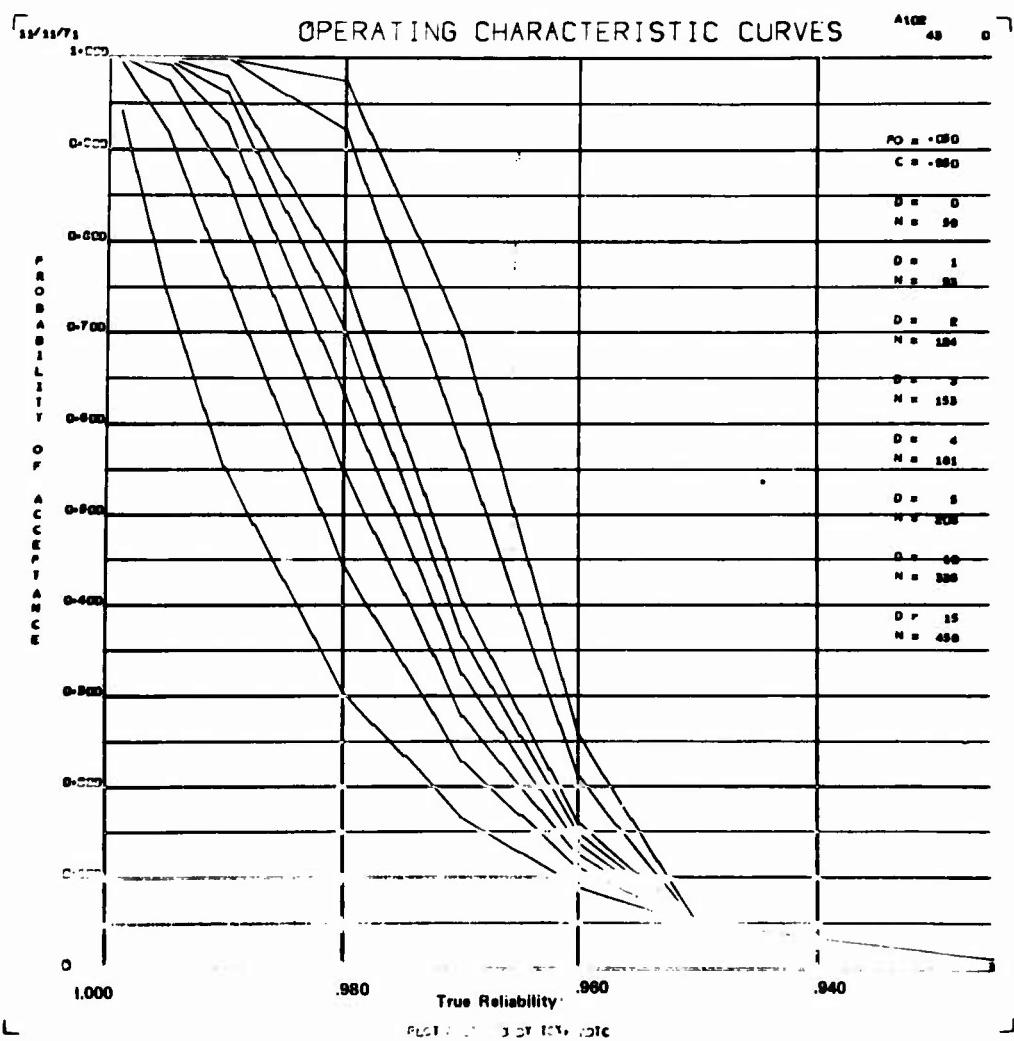


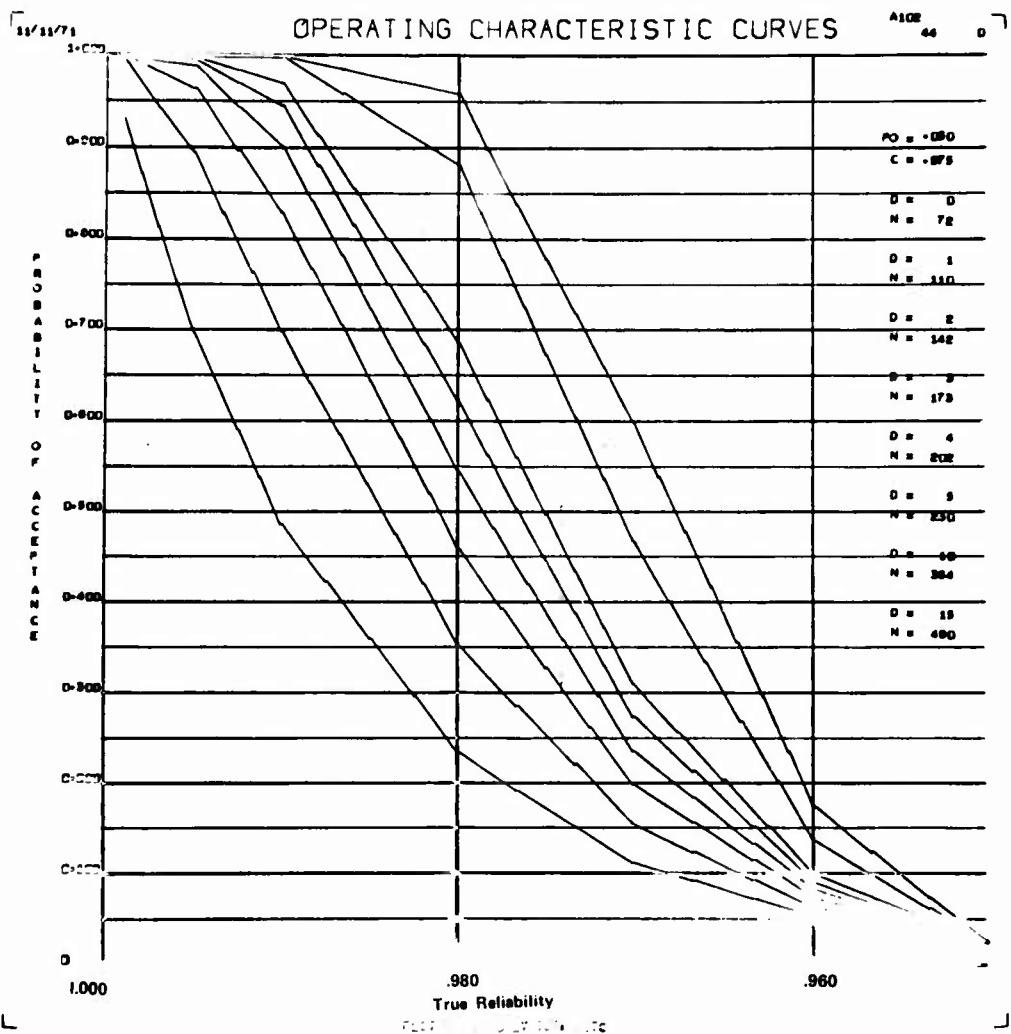


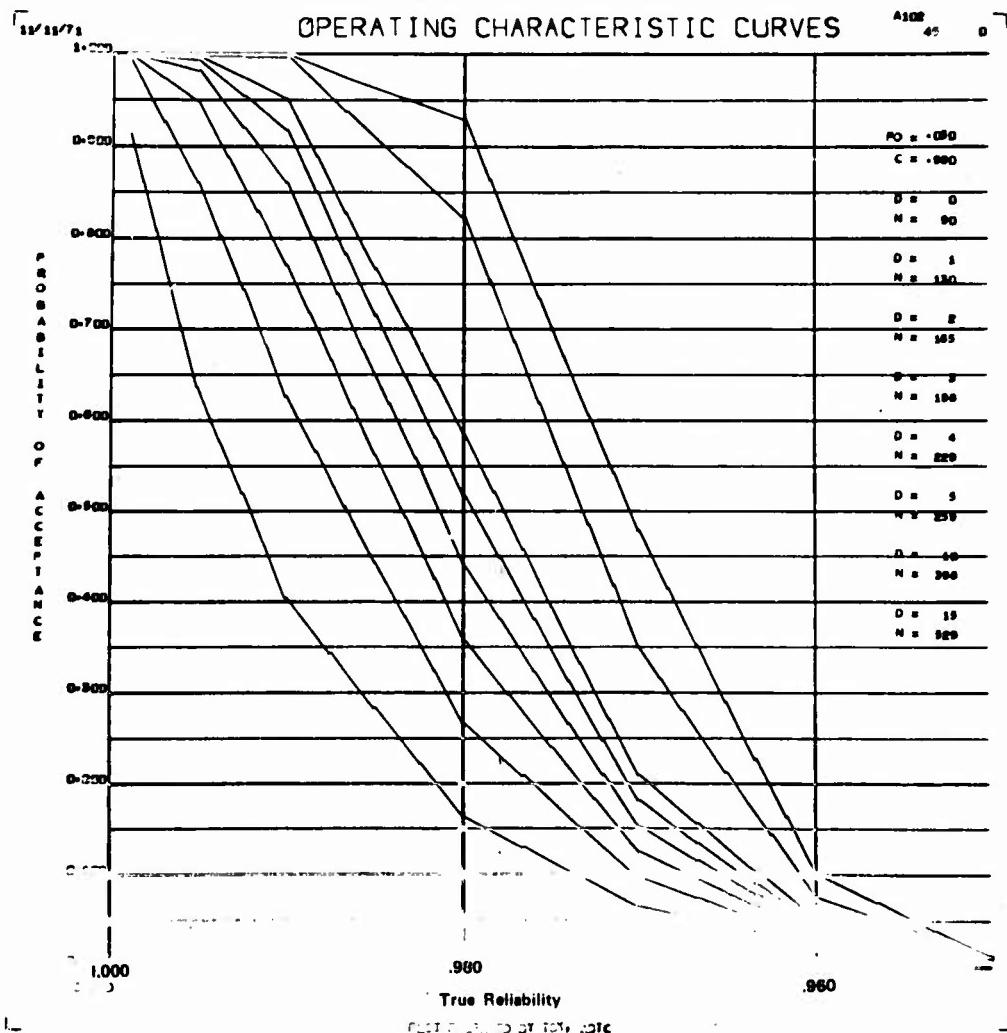






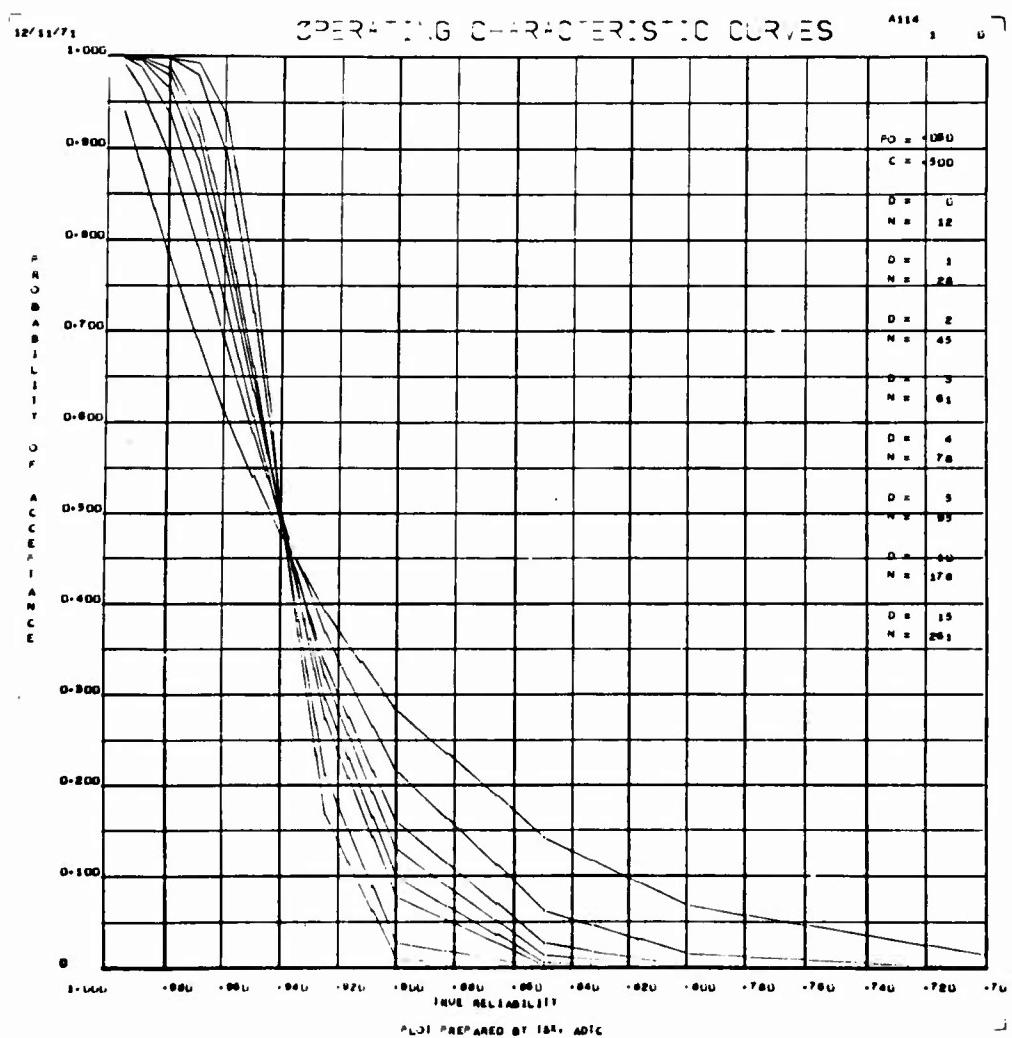


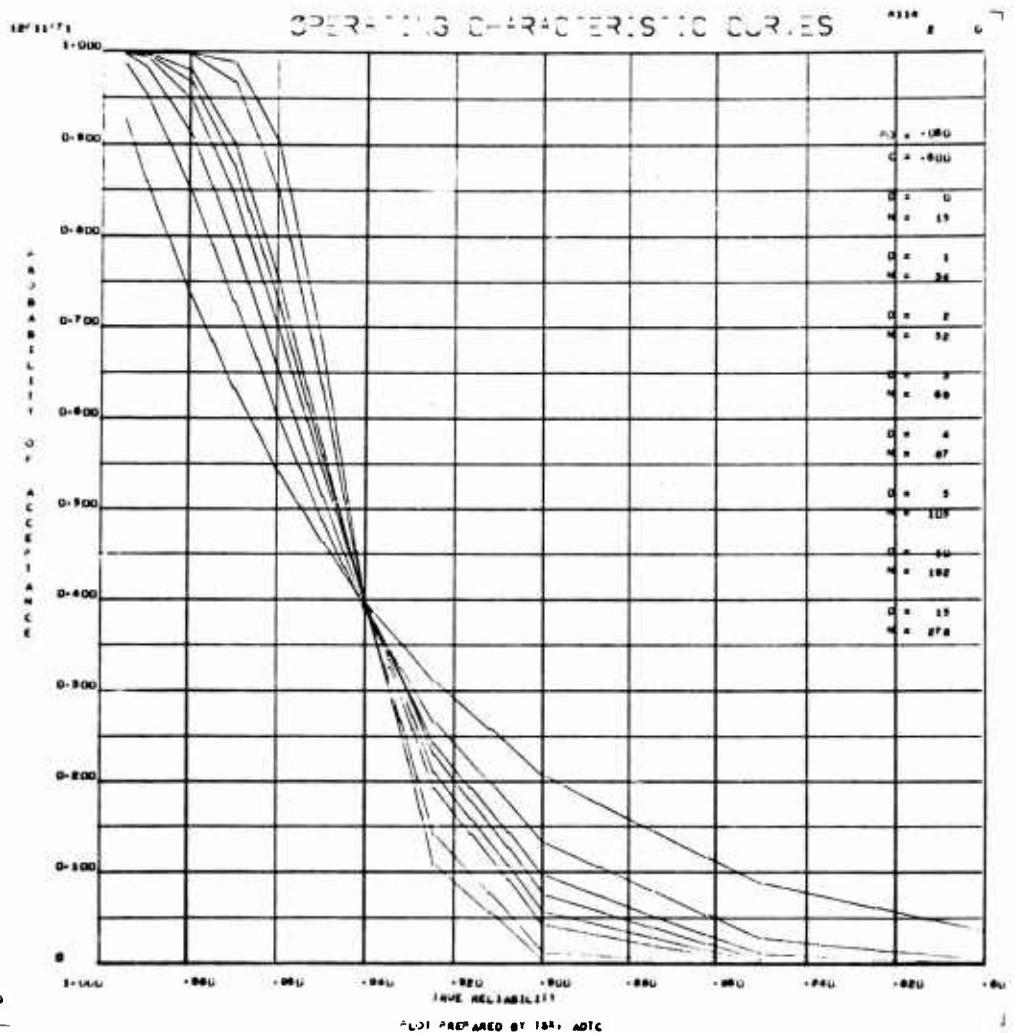




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**OPERATING CHARACTERISTIC
CURVES ($p_0 = .060$)**

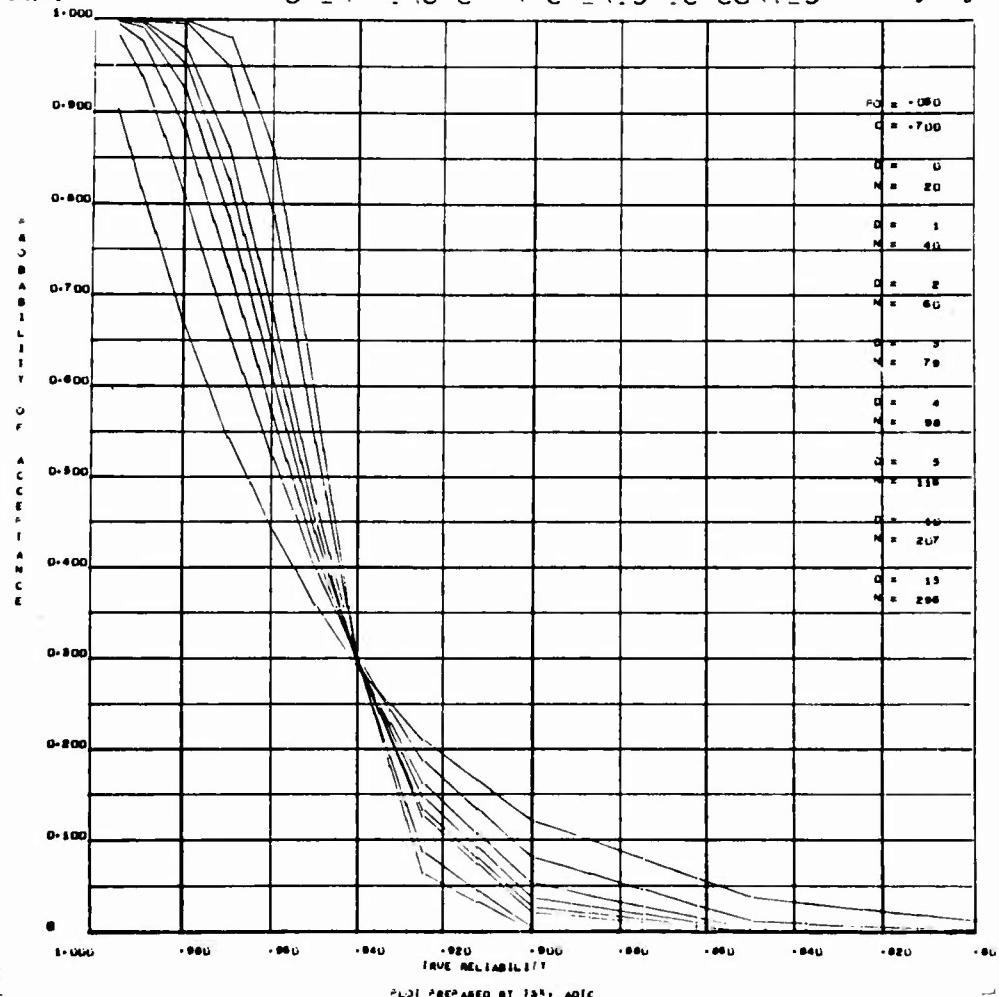


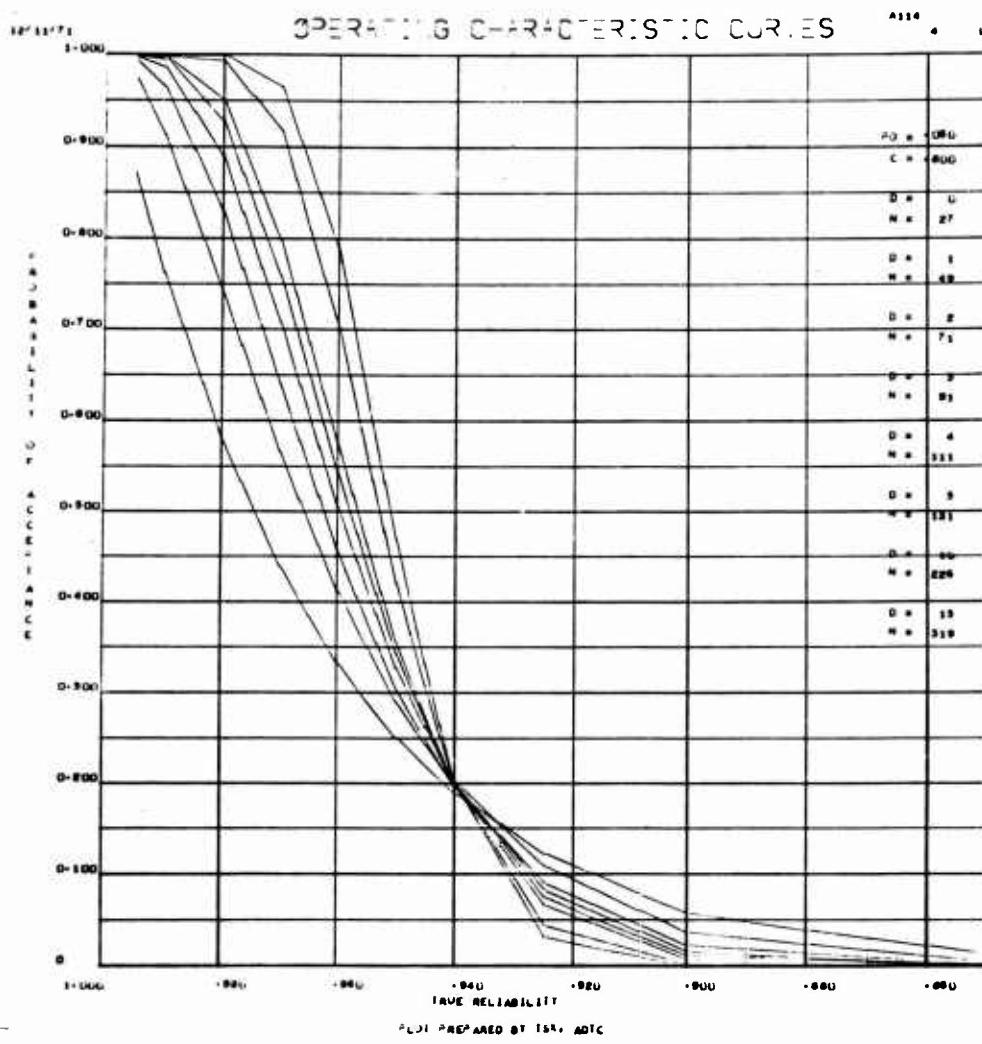


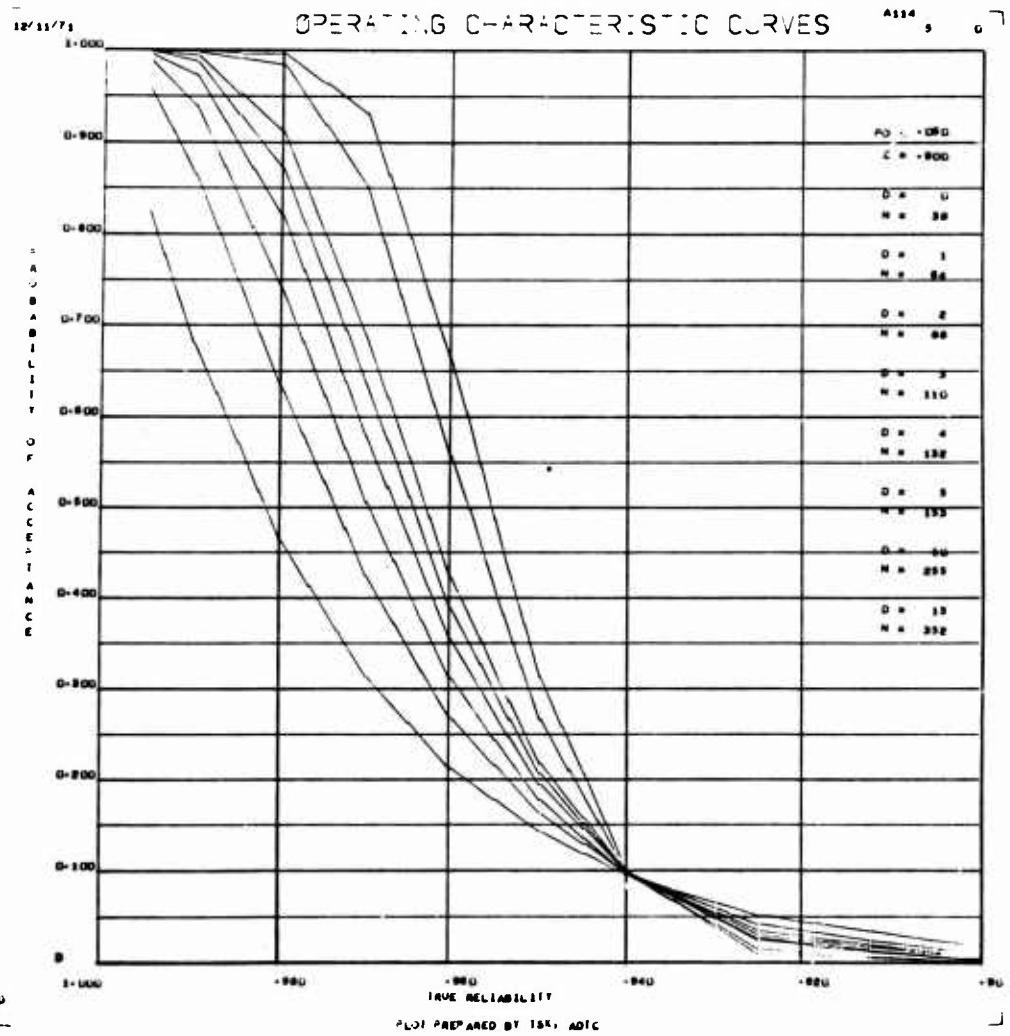
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OPERATING CHARACTERISTIC CURVES

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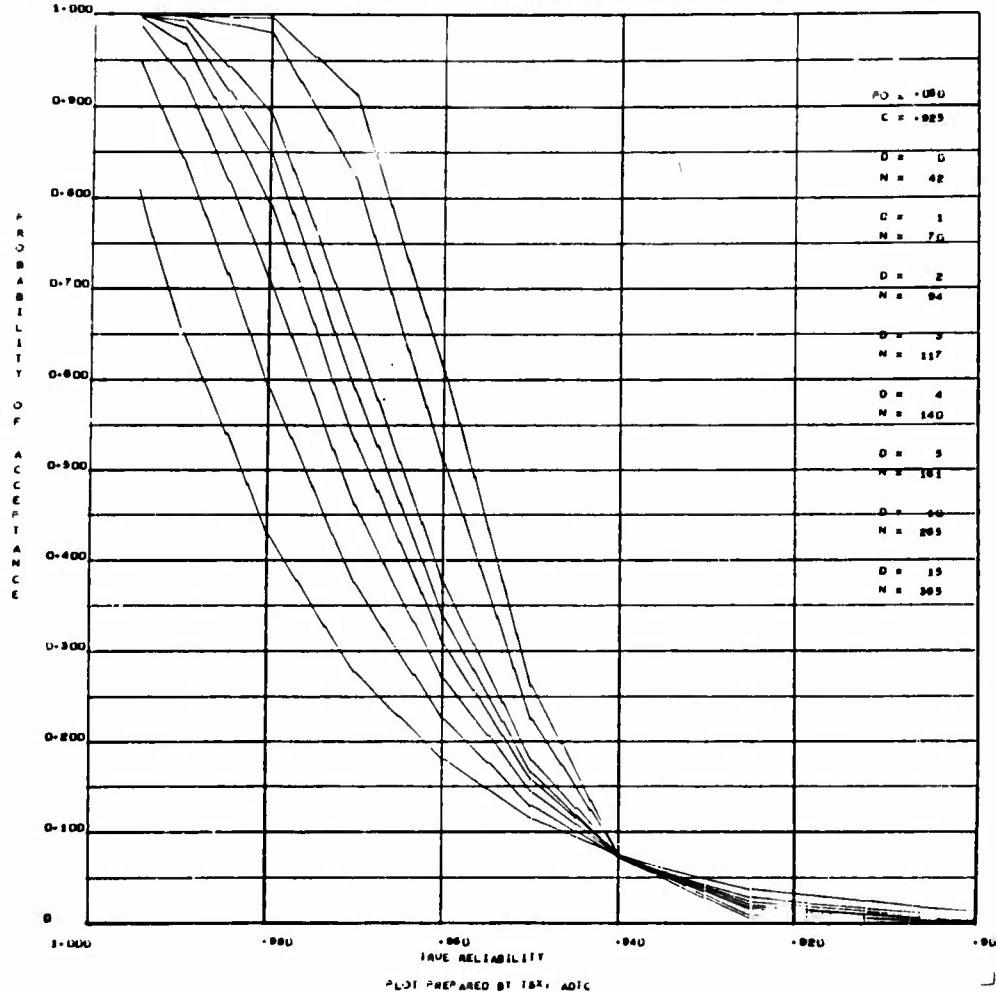


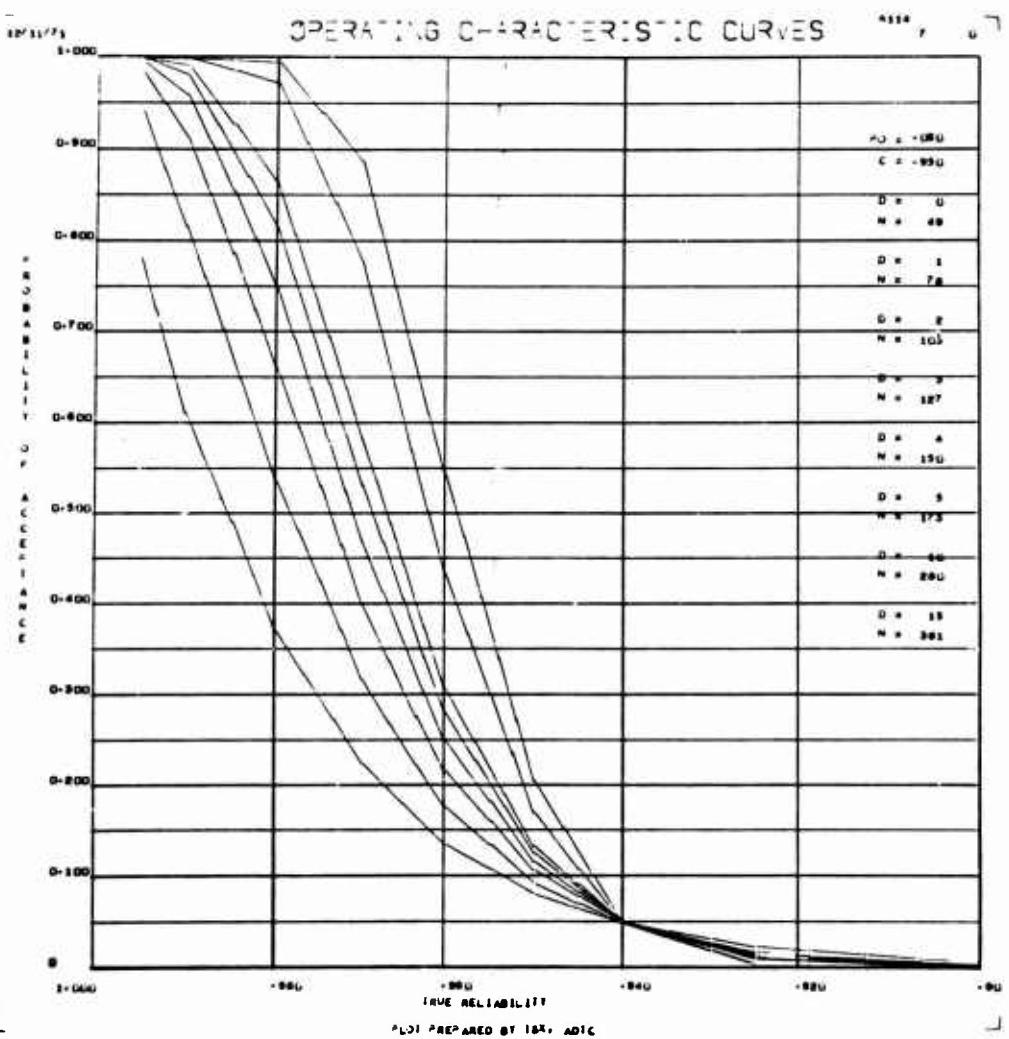


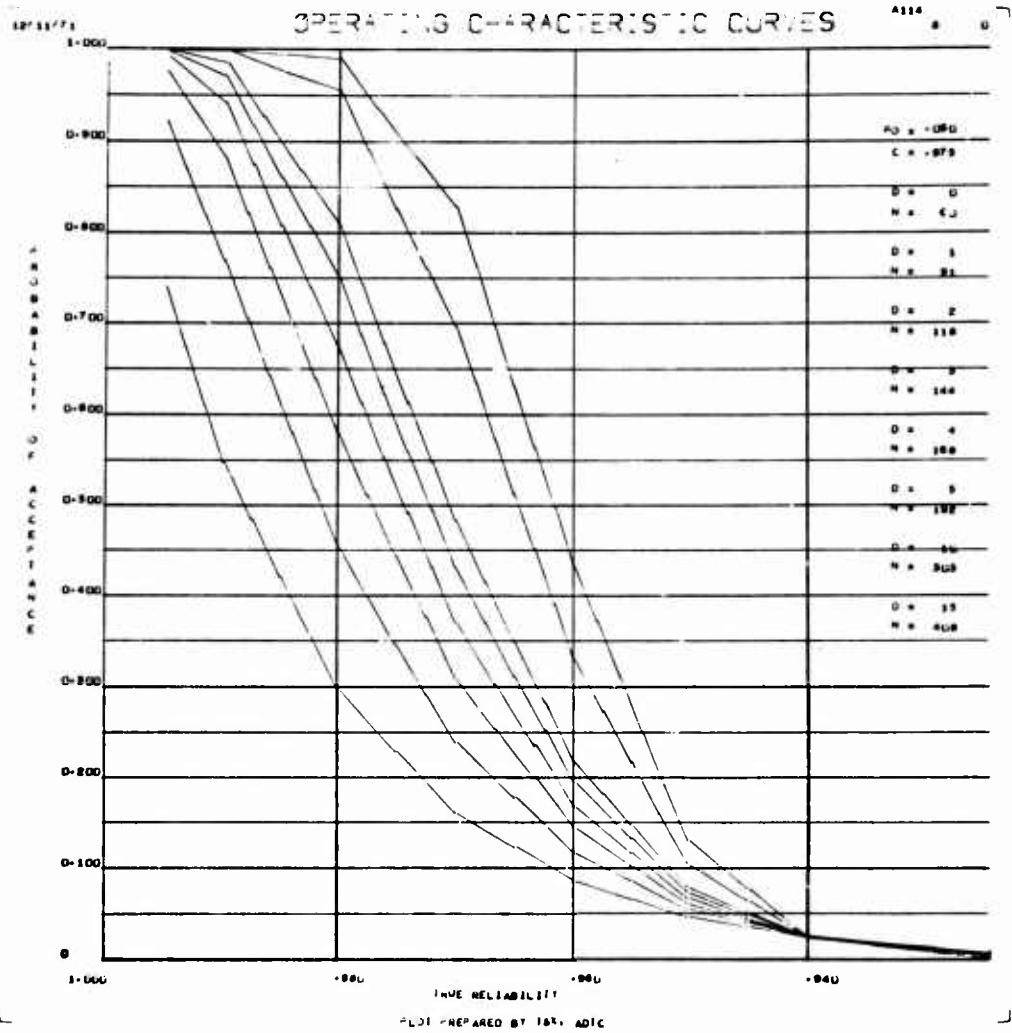
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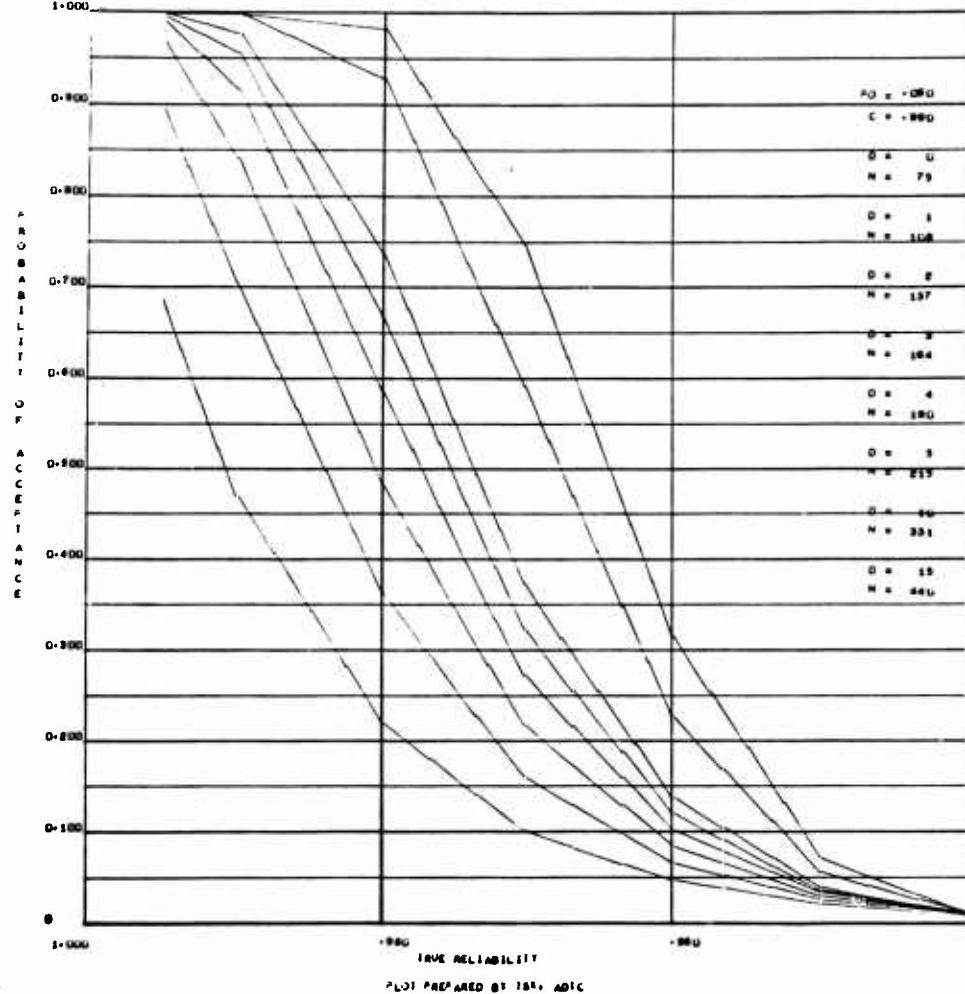




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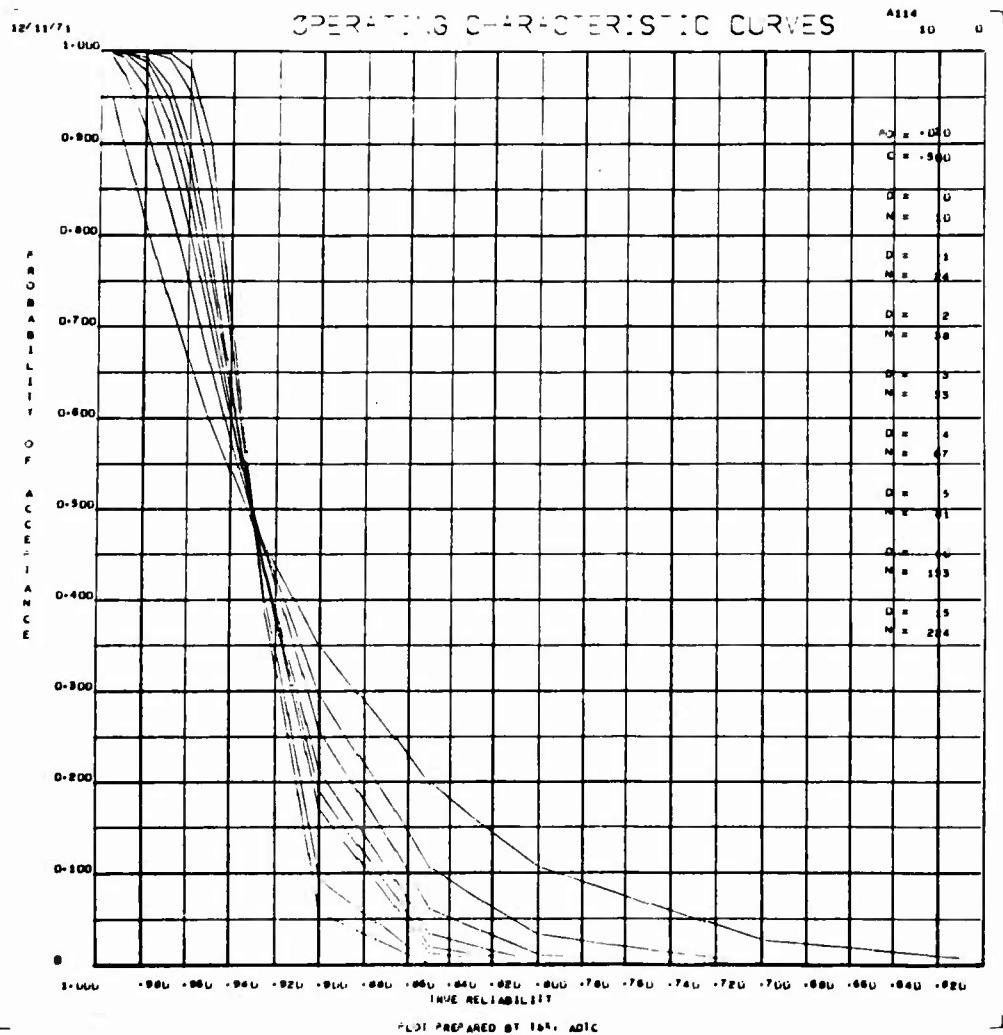
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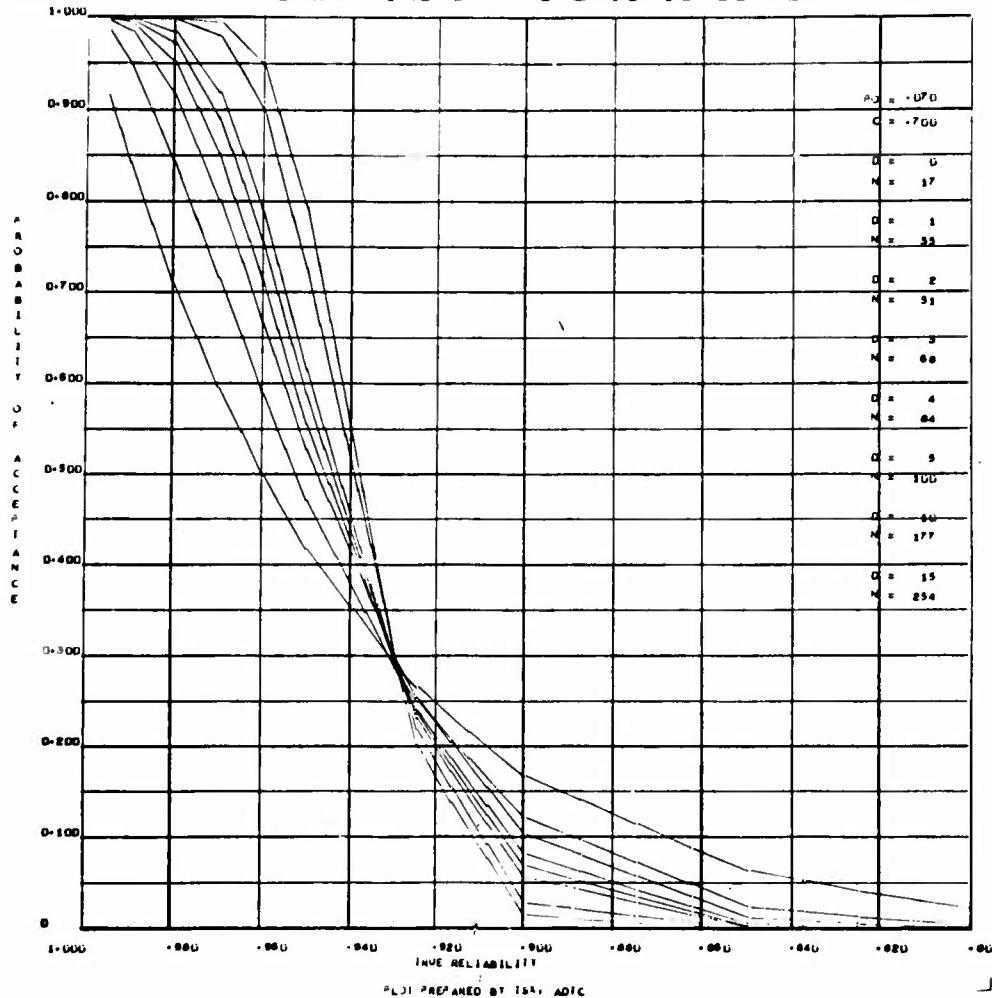
APPENDIX VII

**OPERATING CHARACTERISTIC
CURVES ($p_0 = .070$)**



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OPERATING CHARACTERISTIC CURVES

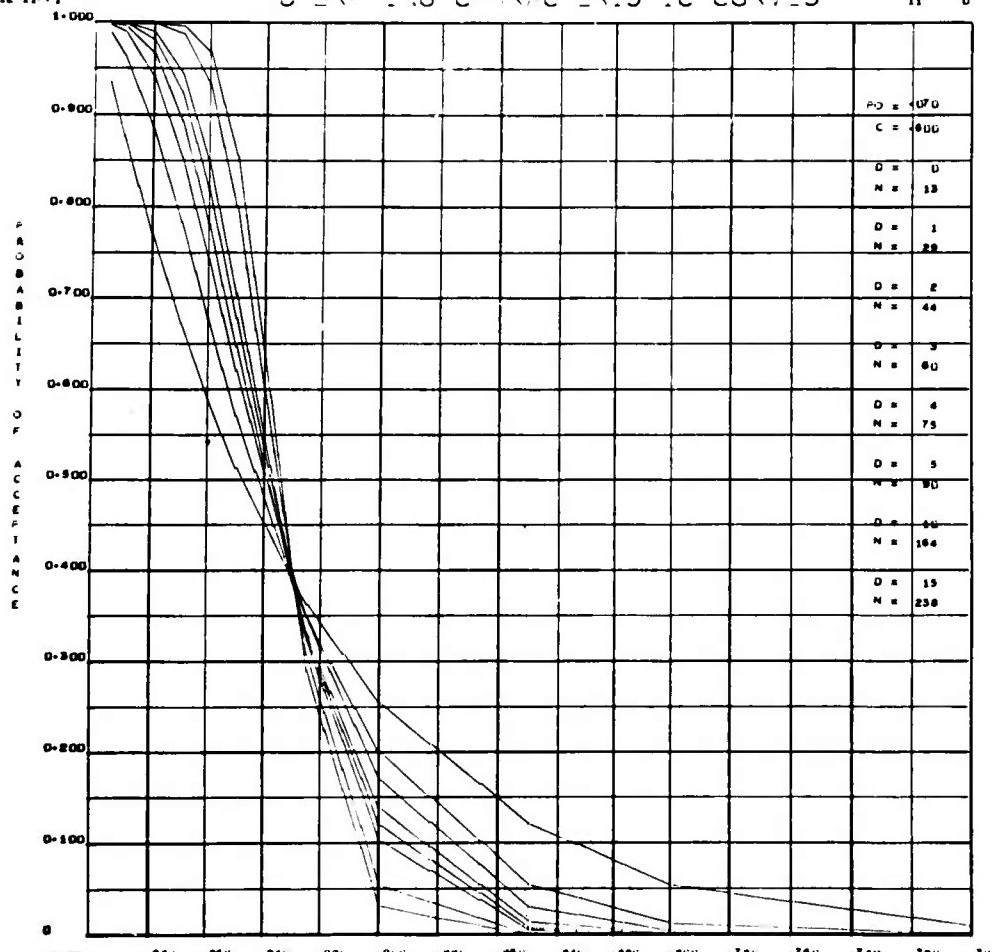
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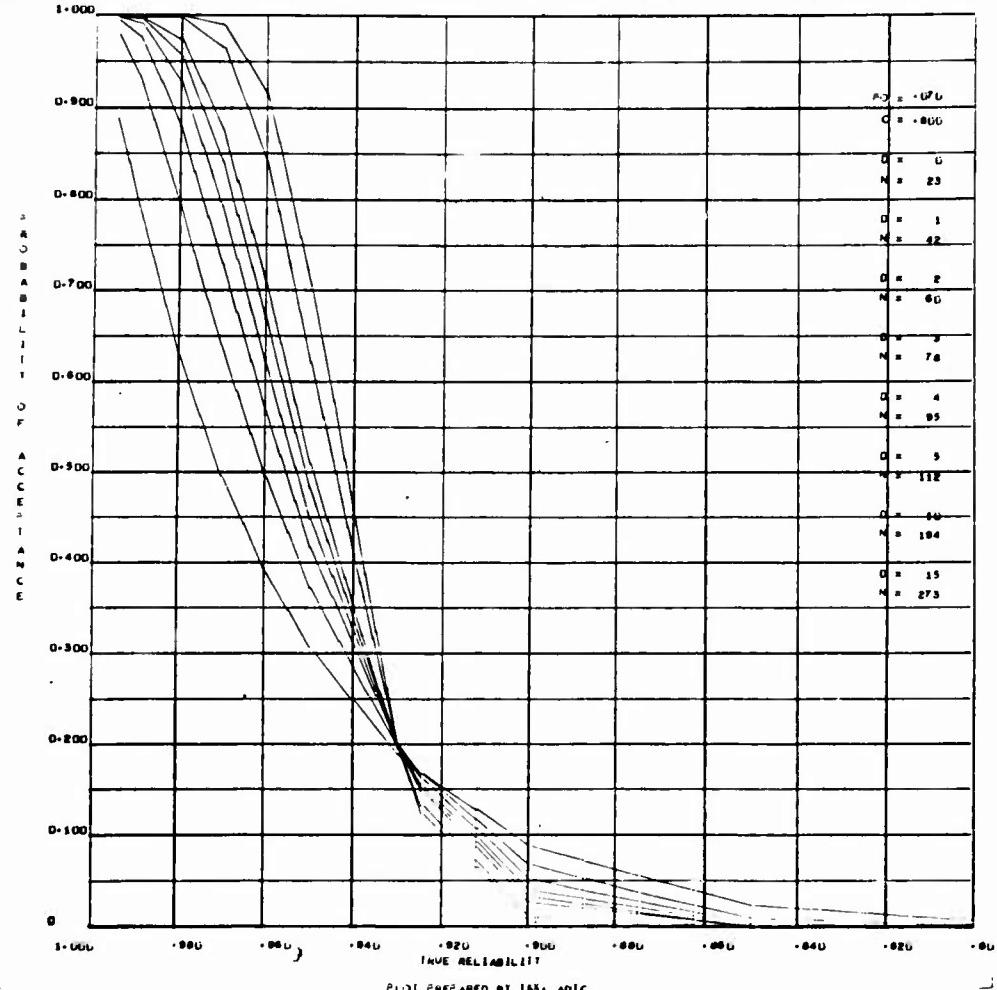
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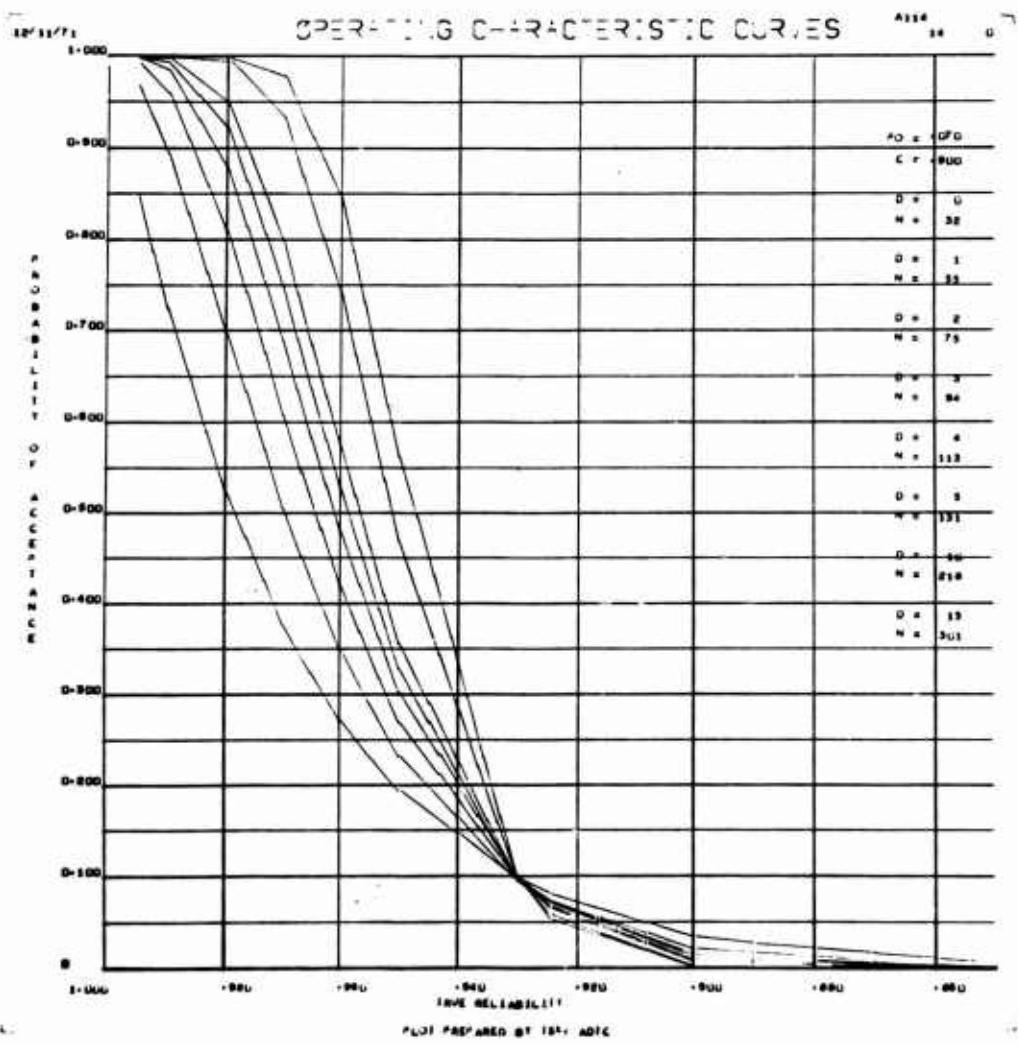


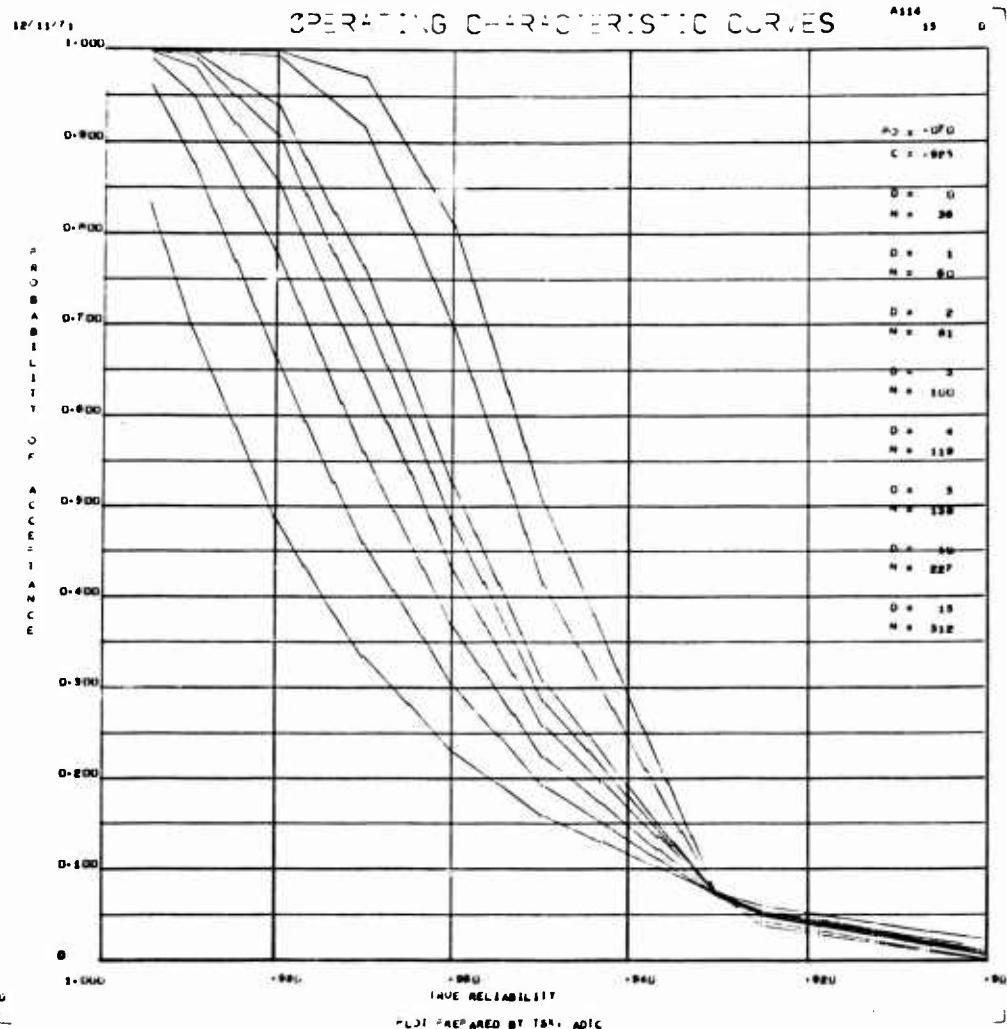
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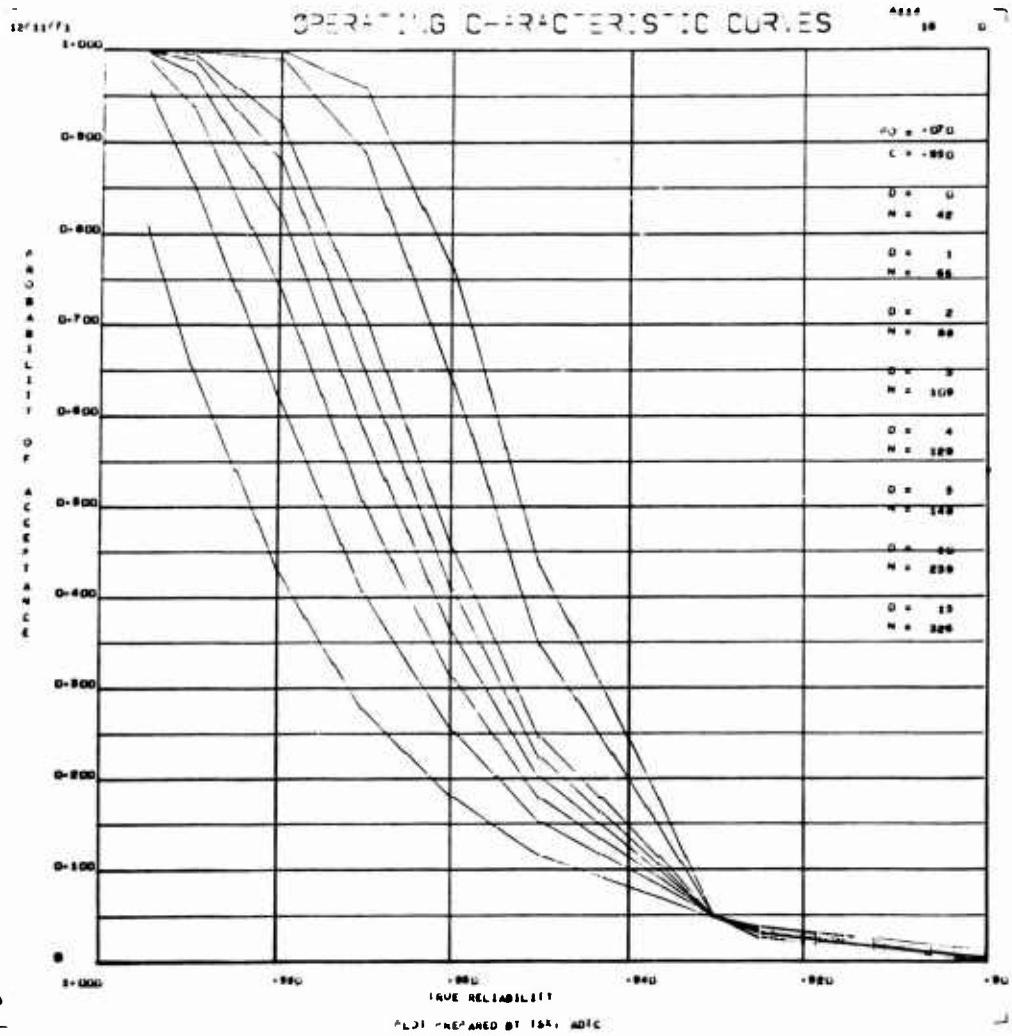
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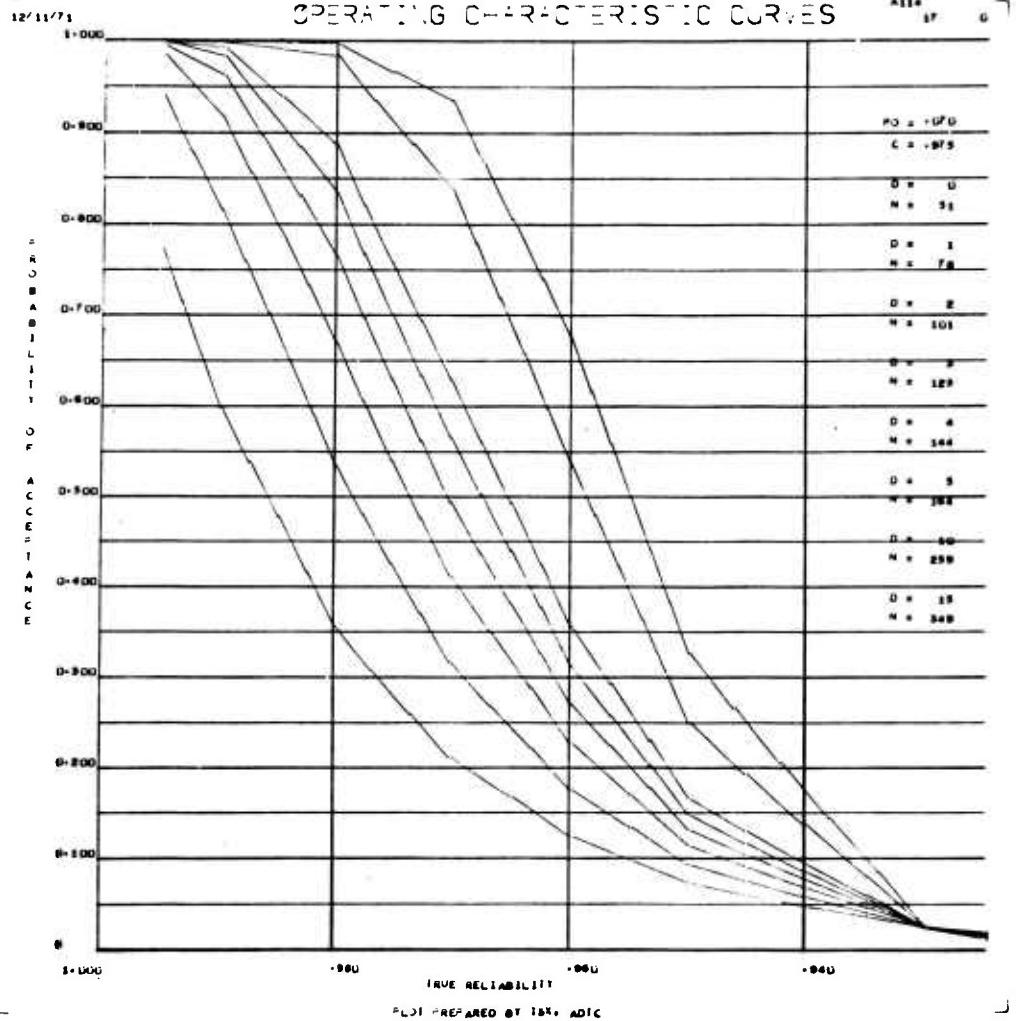
OPERATING CHARACTERISTIC CURVES

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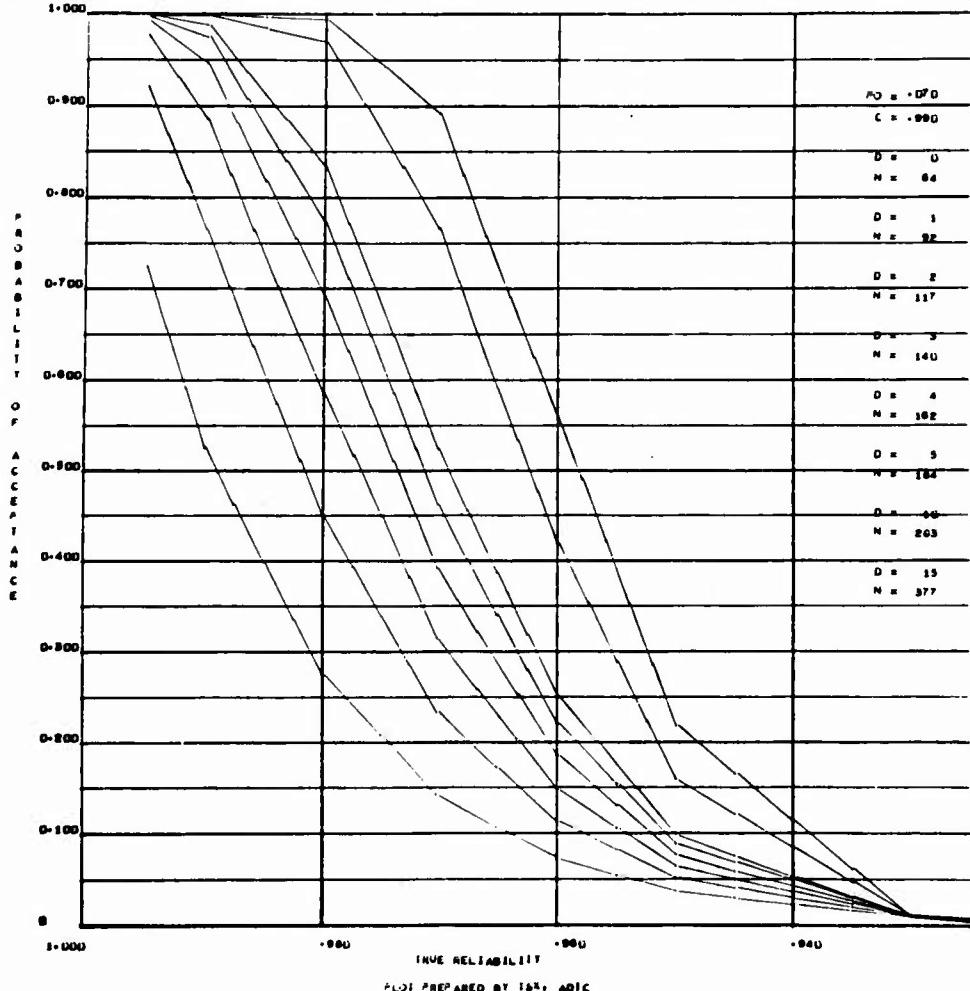




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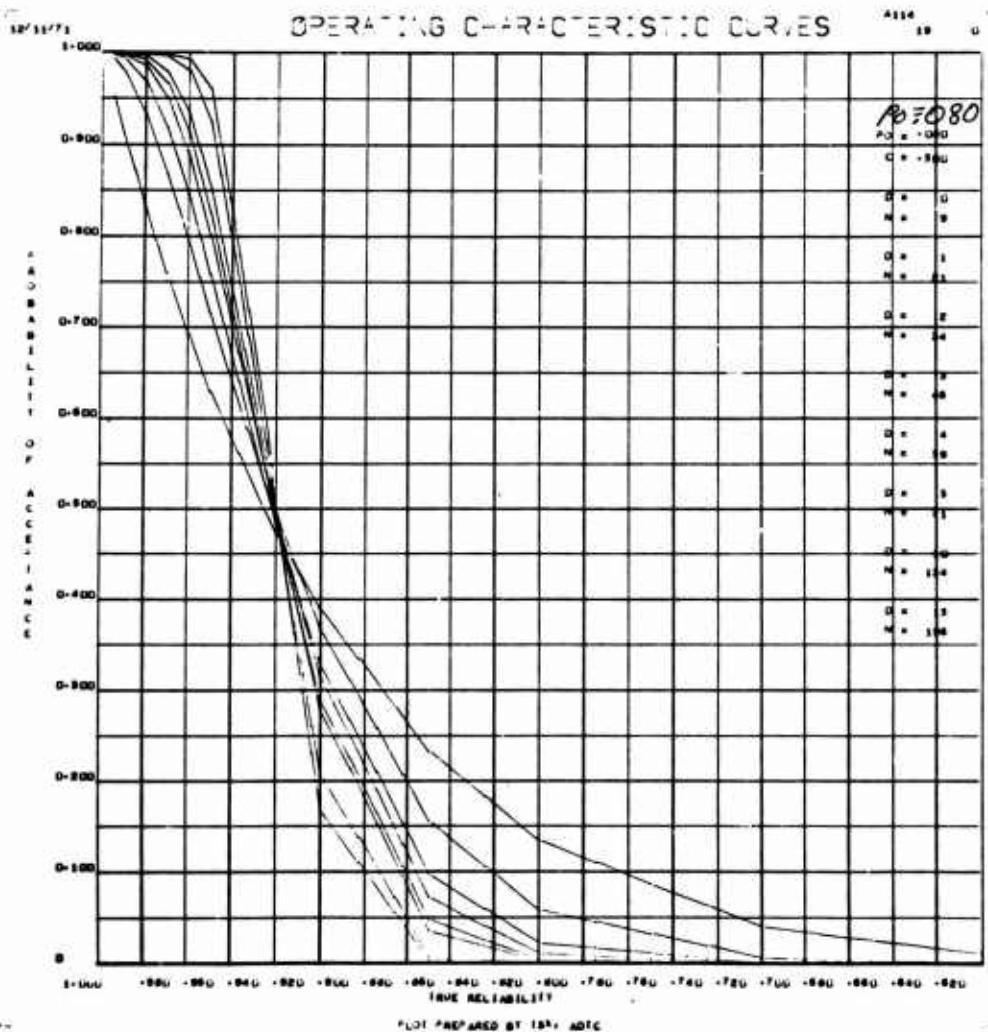
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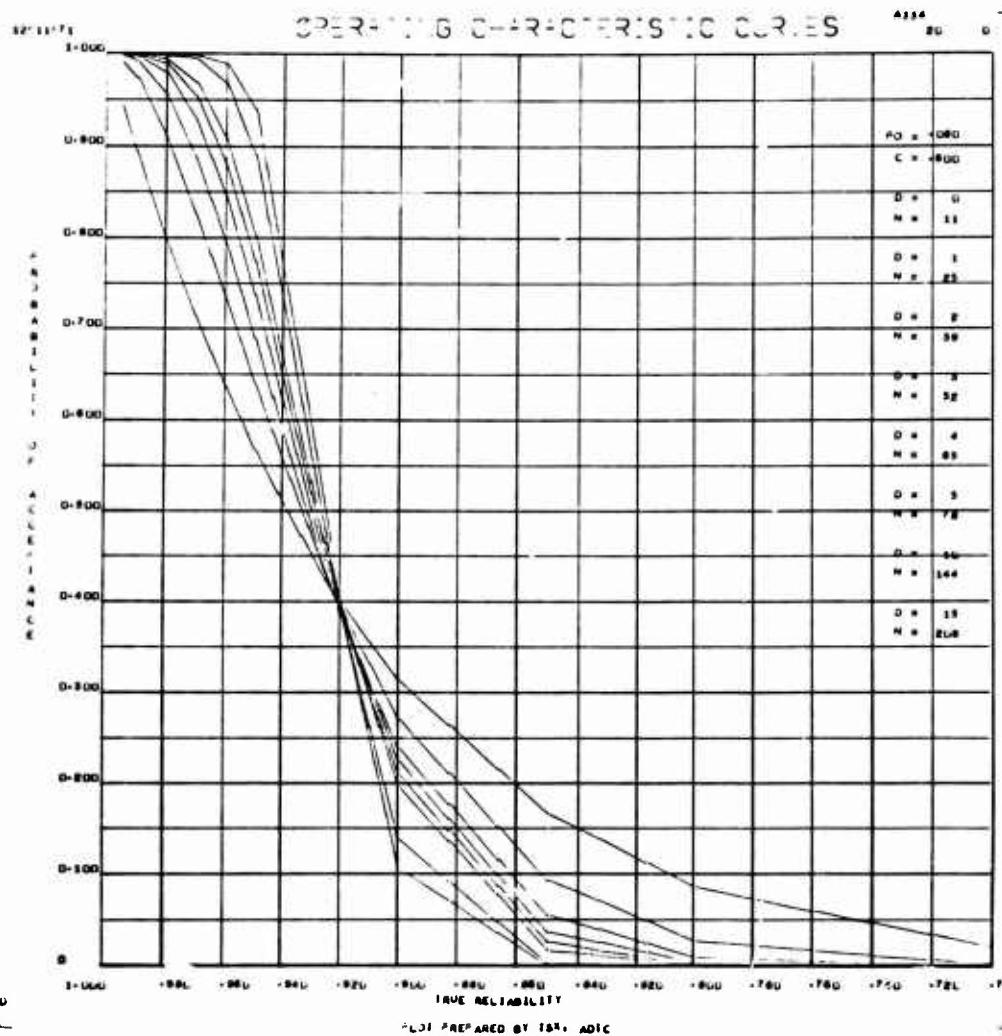
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APPENDIX VIII
OPERATING CHARACTERISTIC
CURVES ($p_0 = .080$)

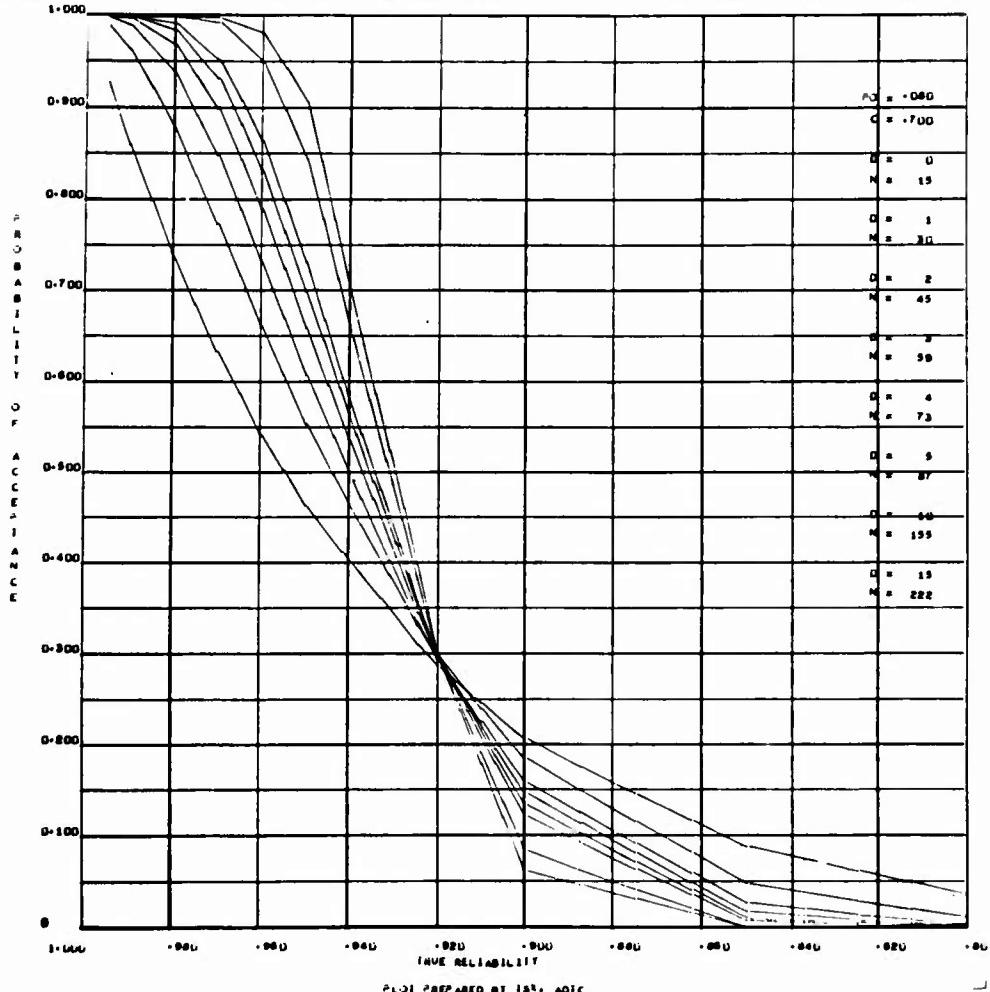




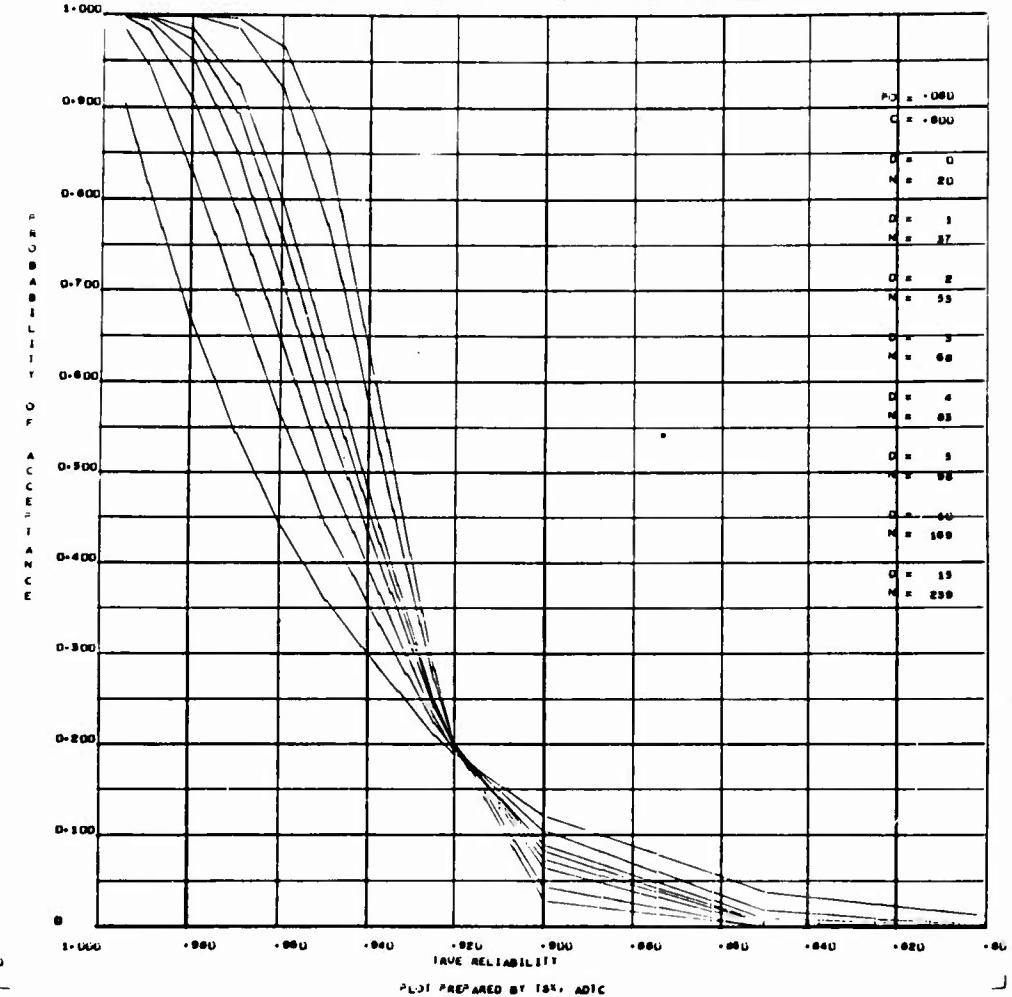
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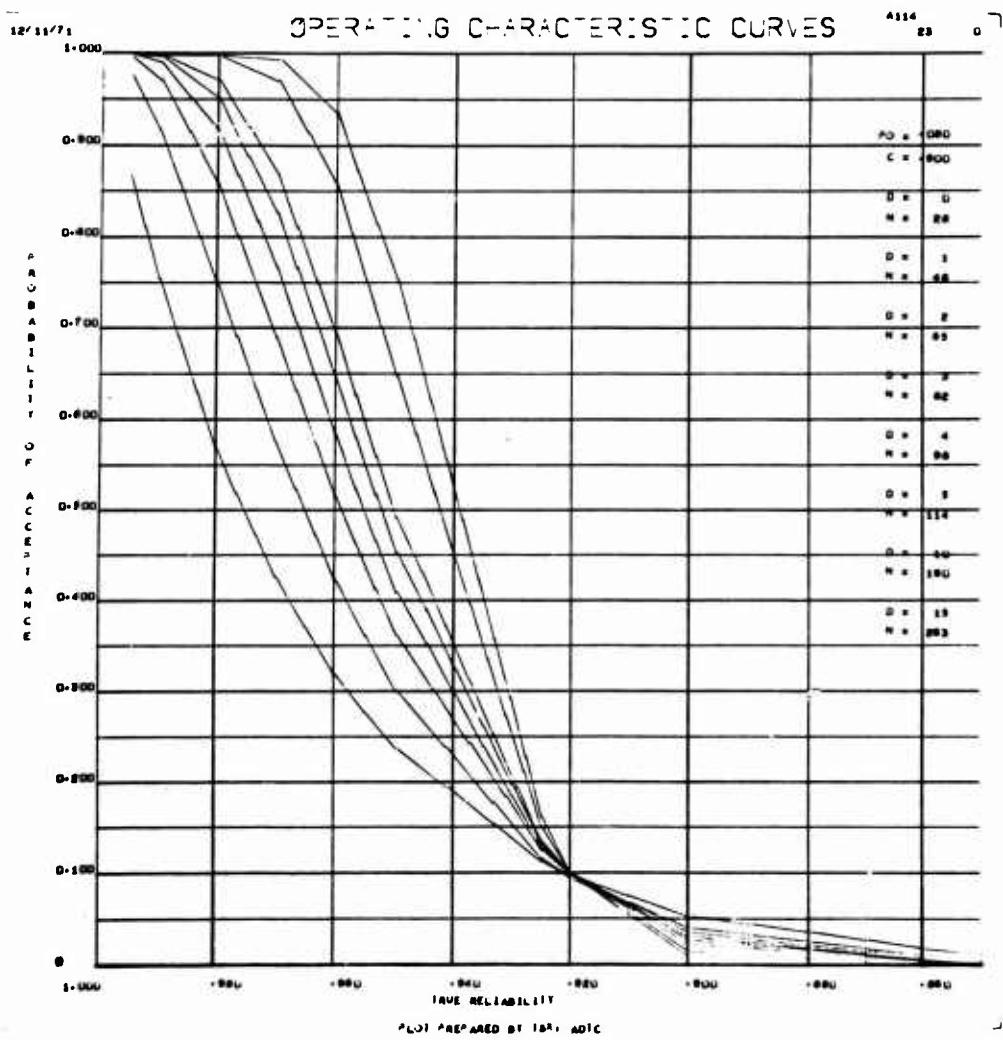
OPERATING CHARACTERISTIC CURVES

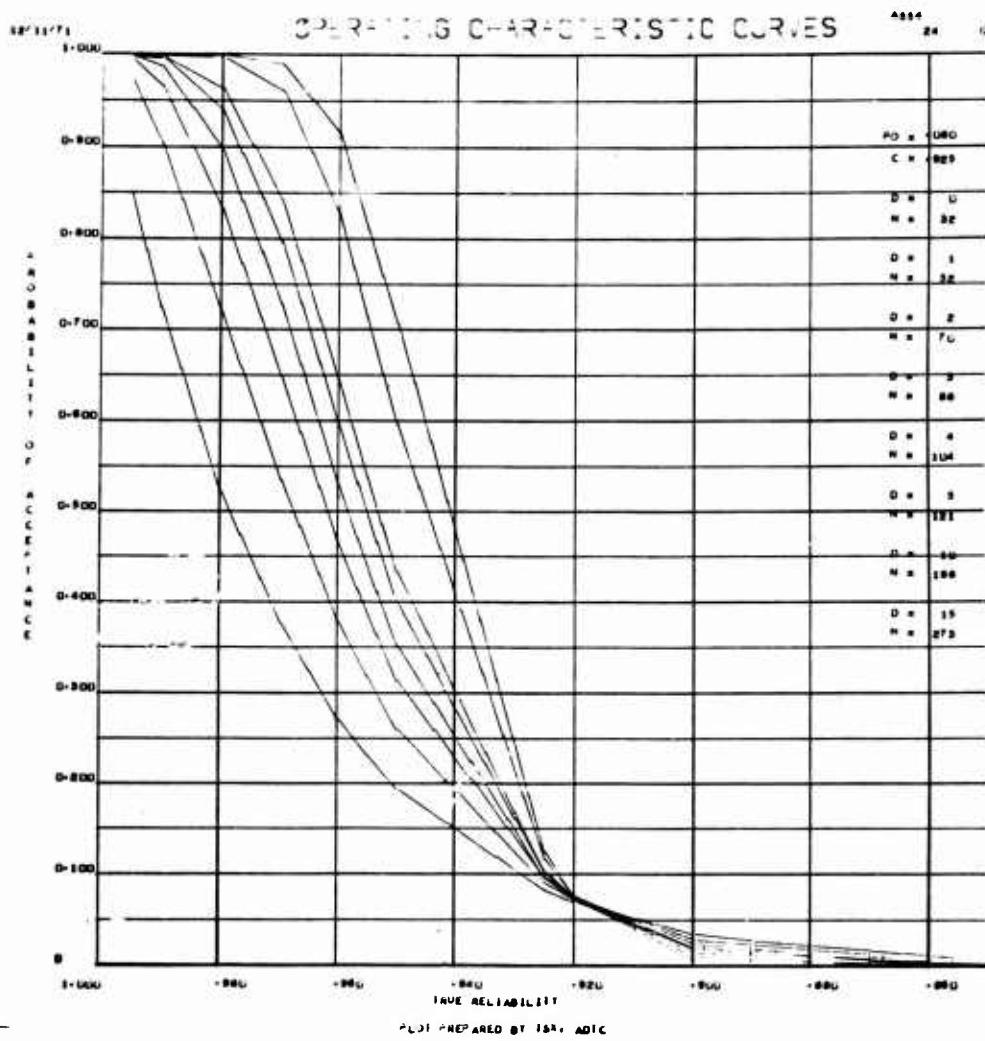
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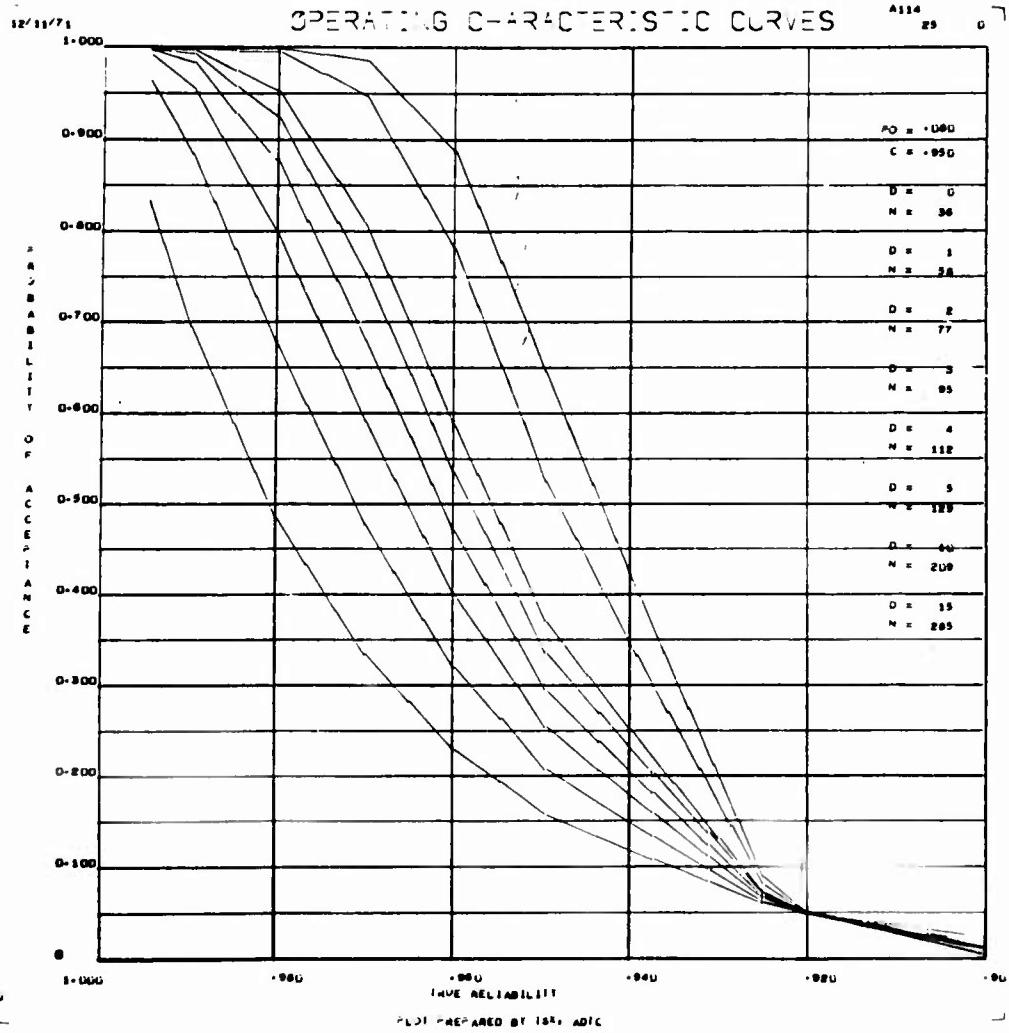


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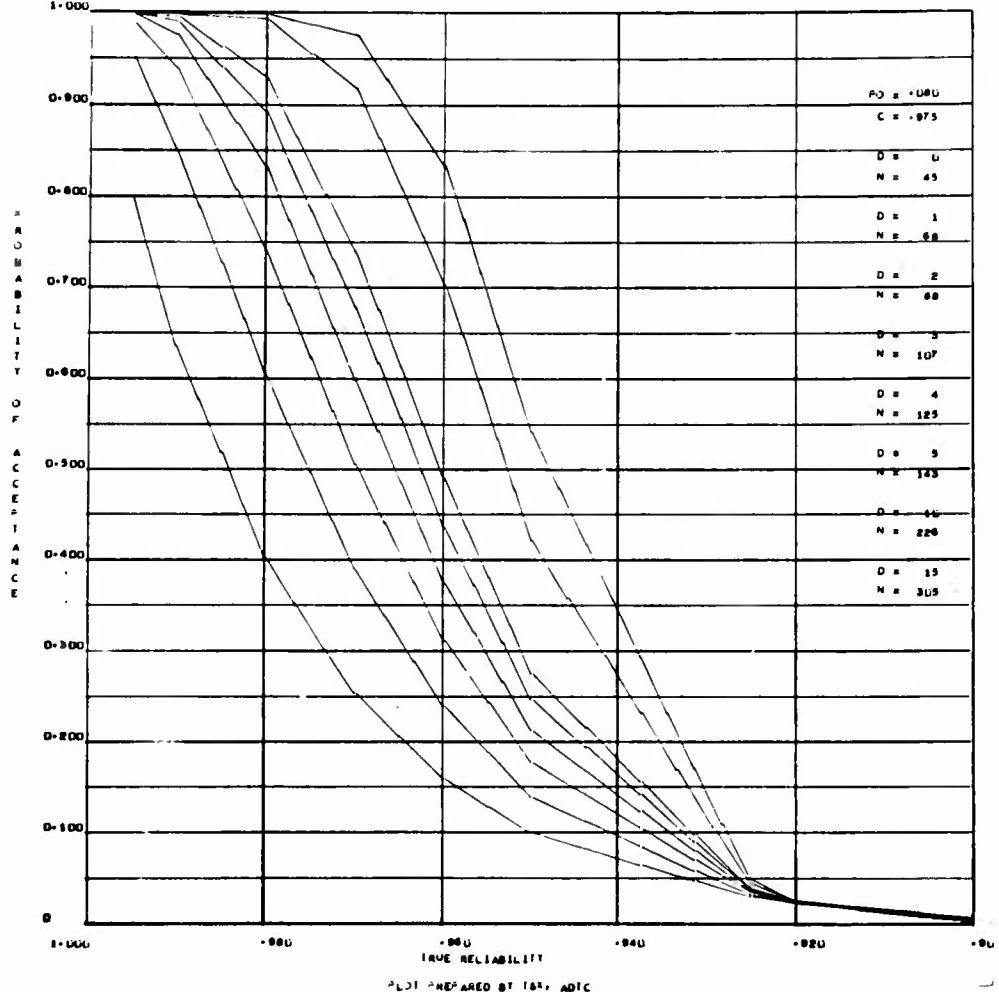


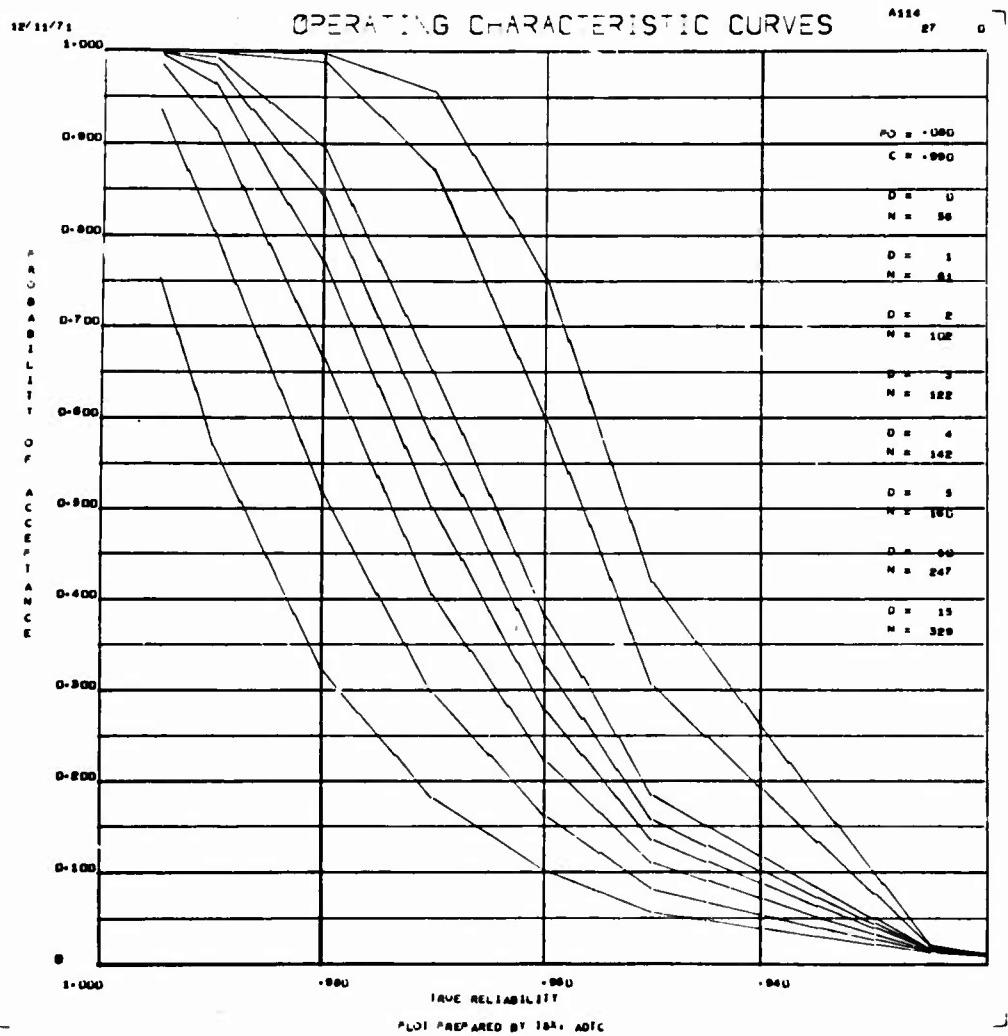


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OPERATING CHARACTERISTIC CURVES

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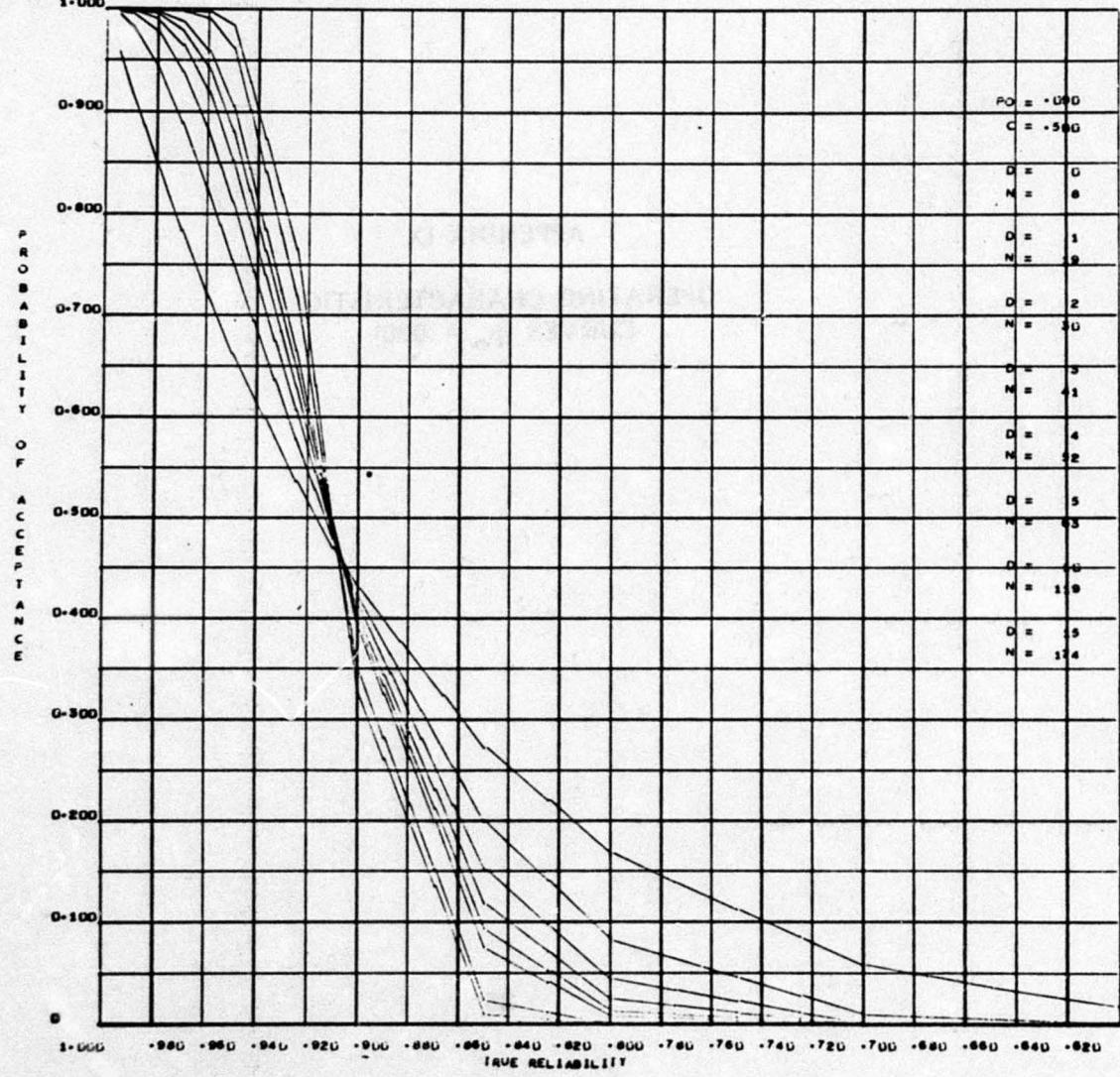


APPENDIX IX
OPERATING CHARACTERISTIC
CURVES ($p_0 = .090$)

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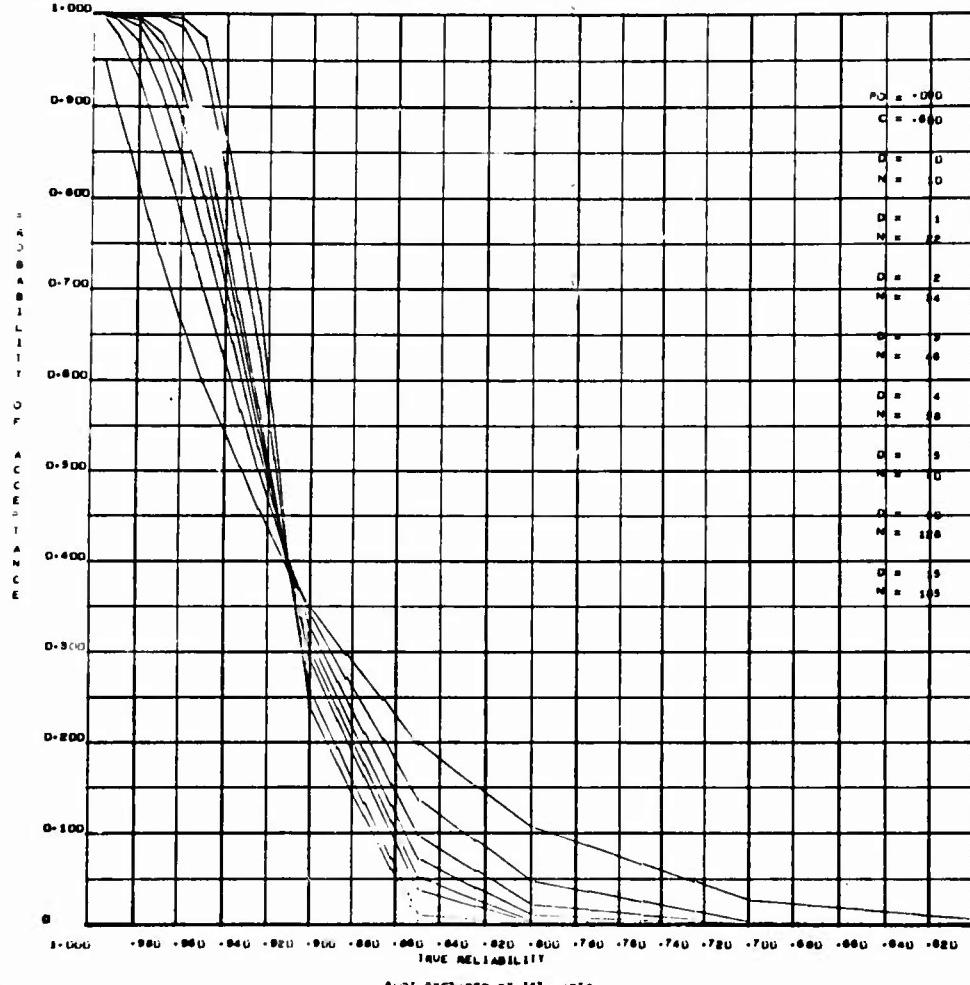


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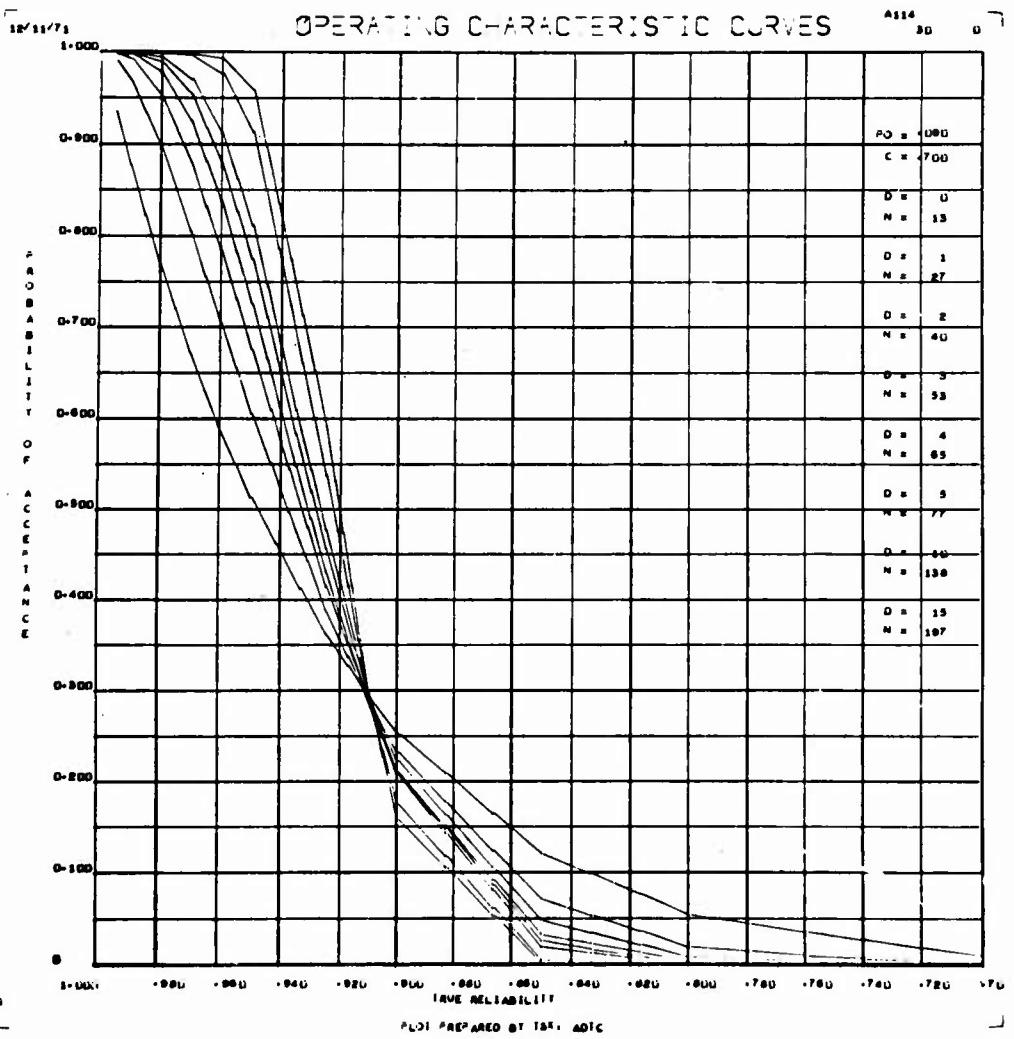
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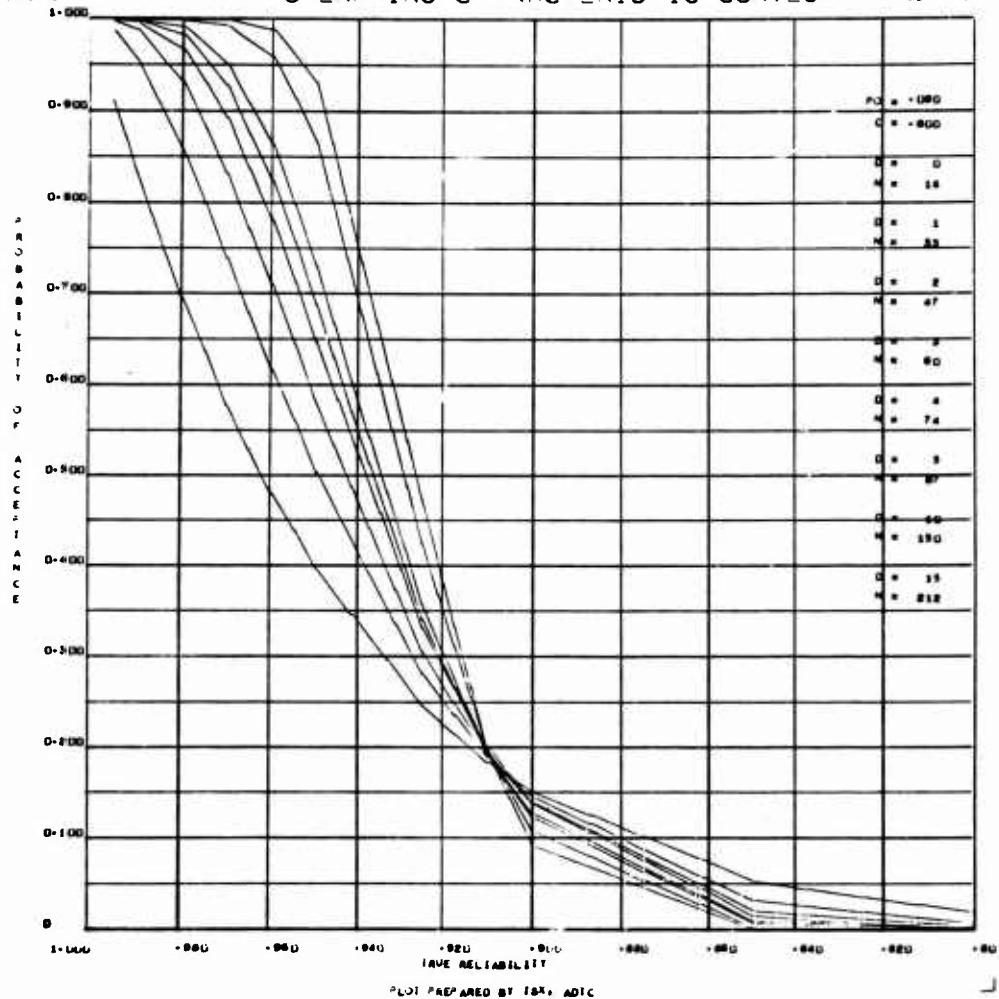
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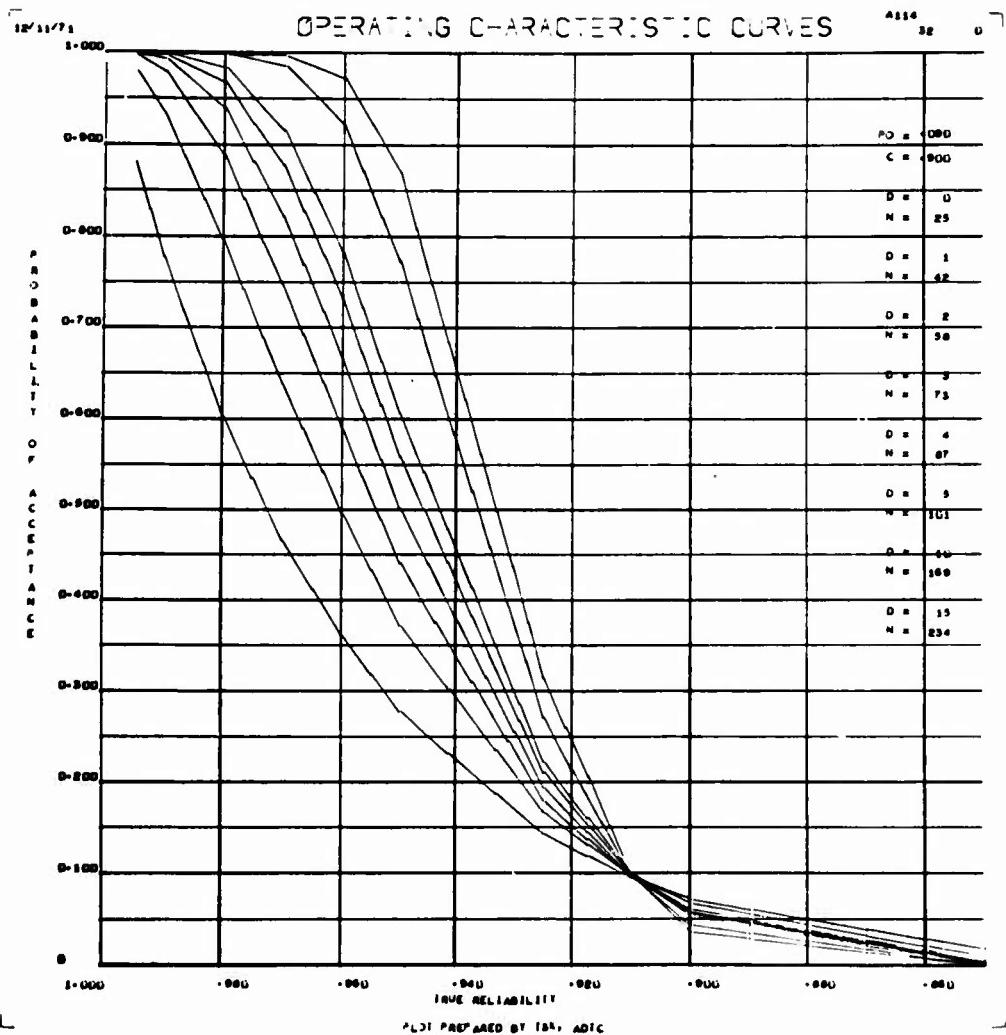
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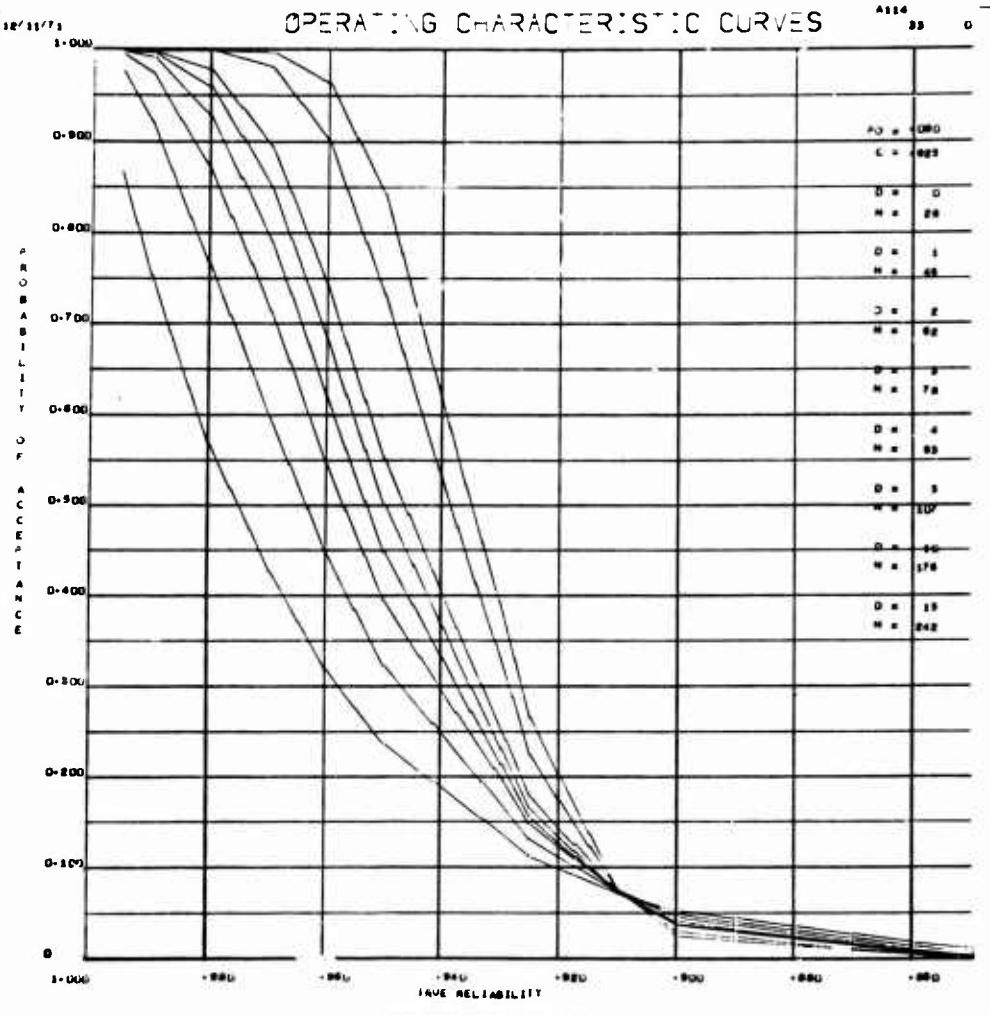
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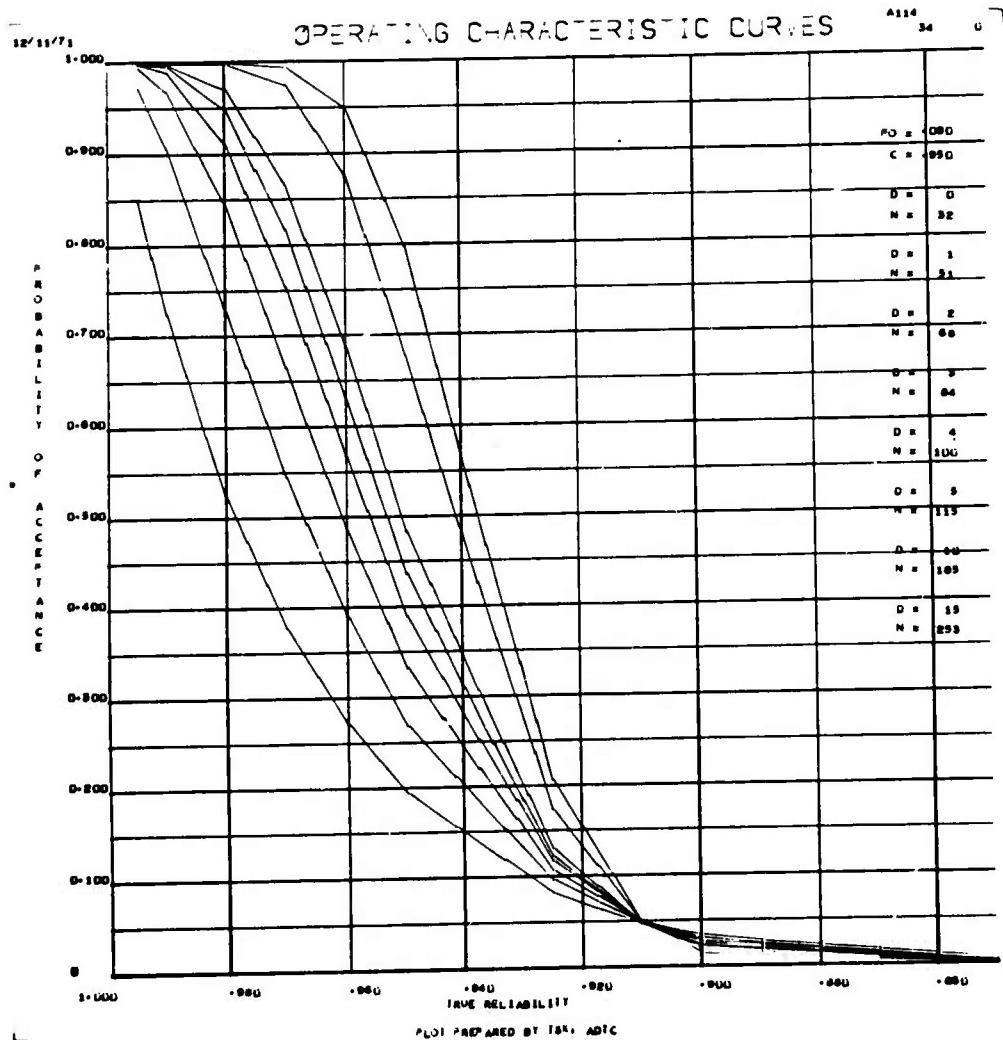


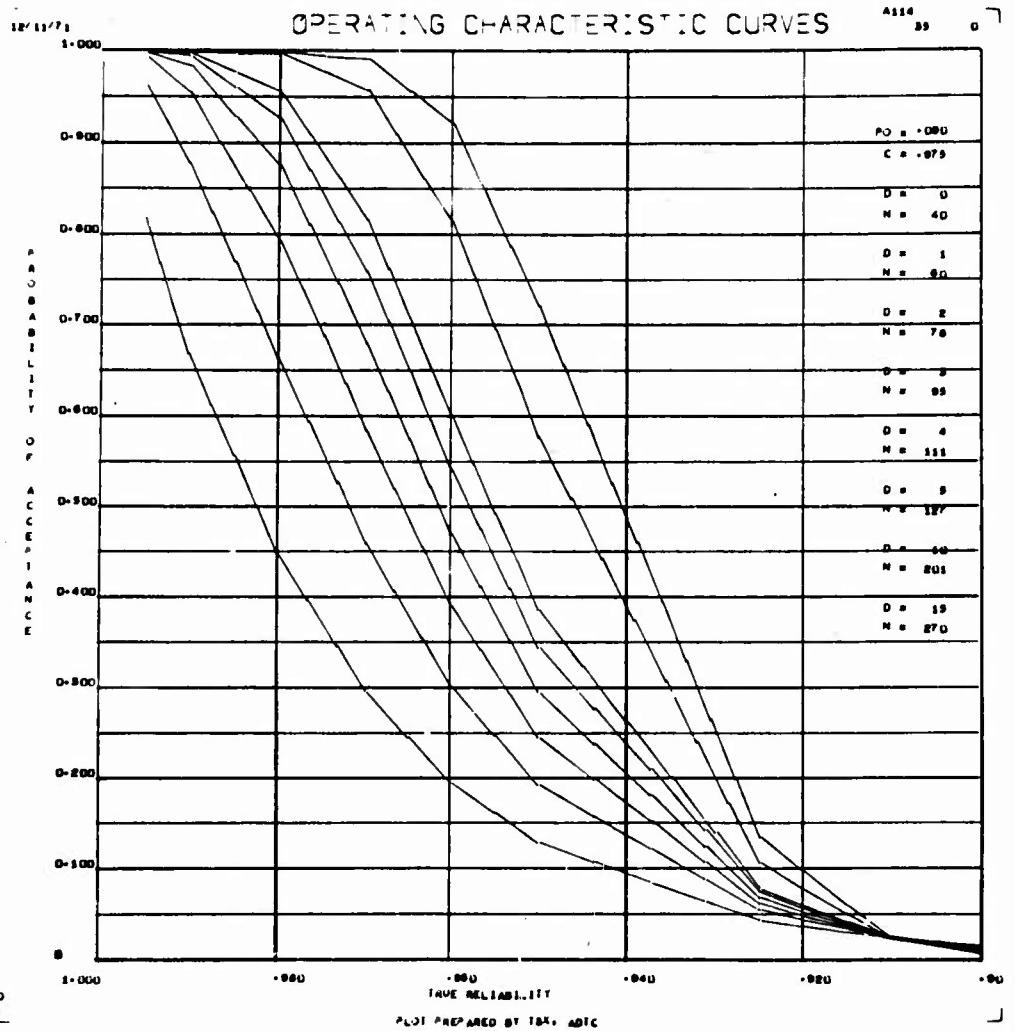
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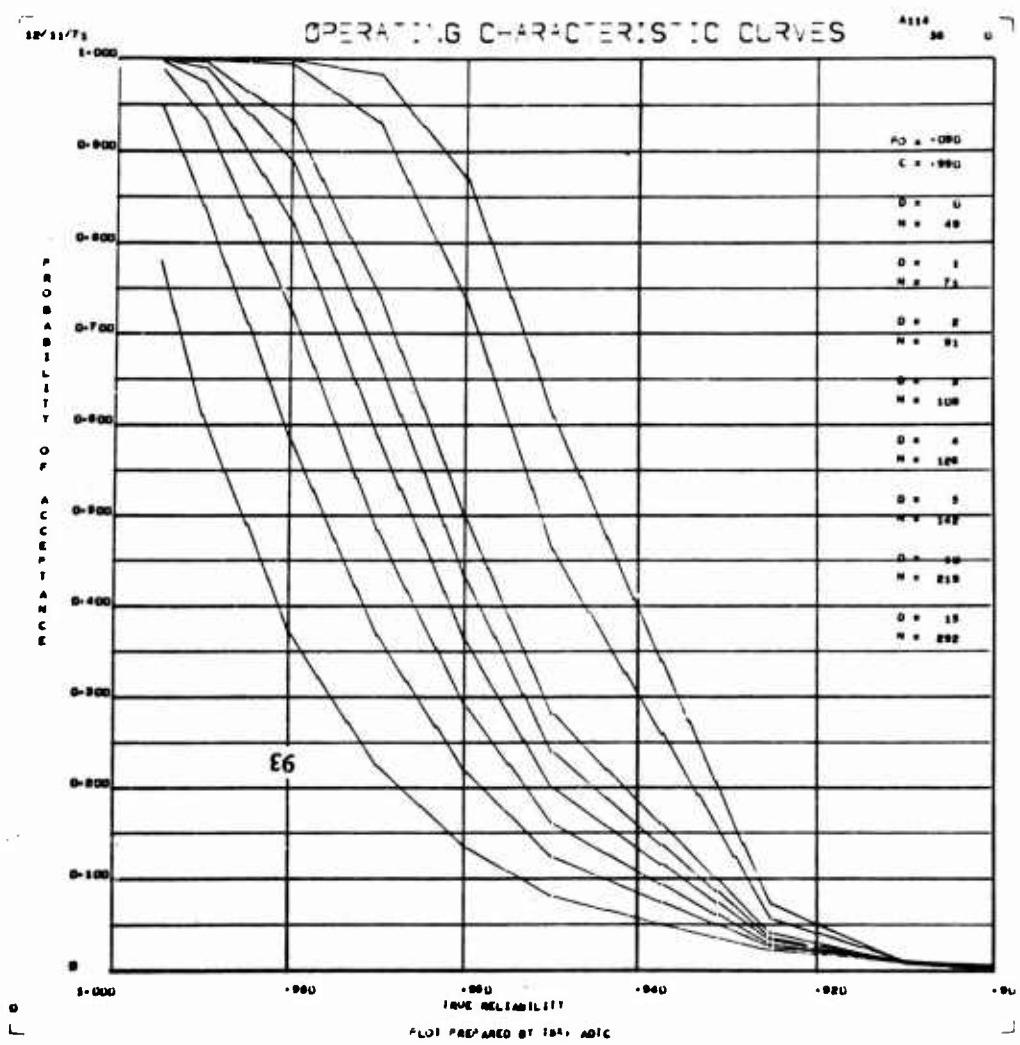


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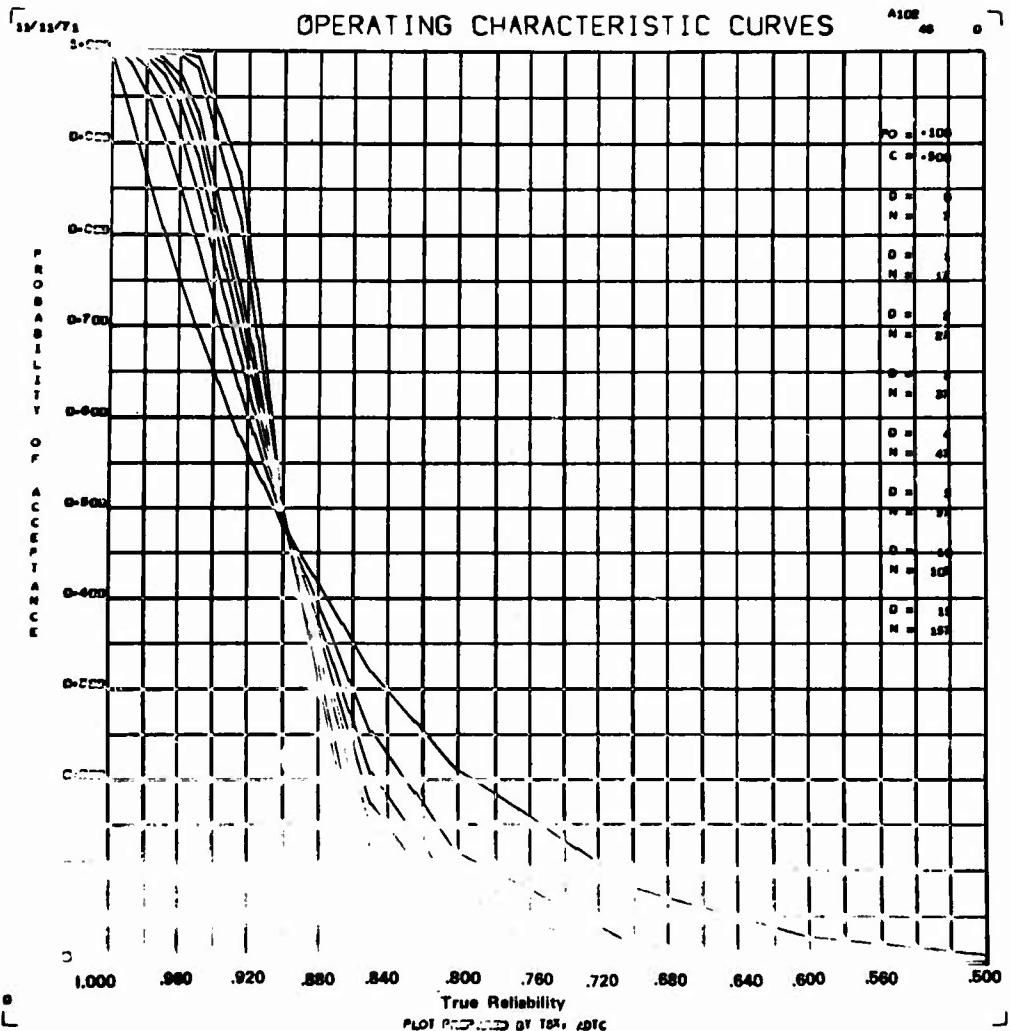


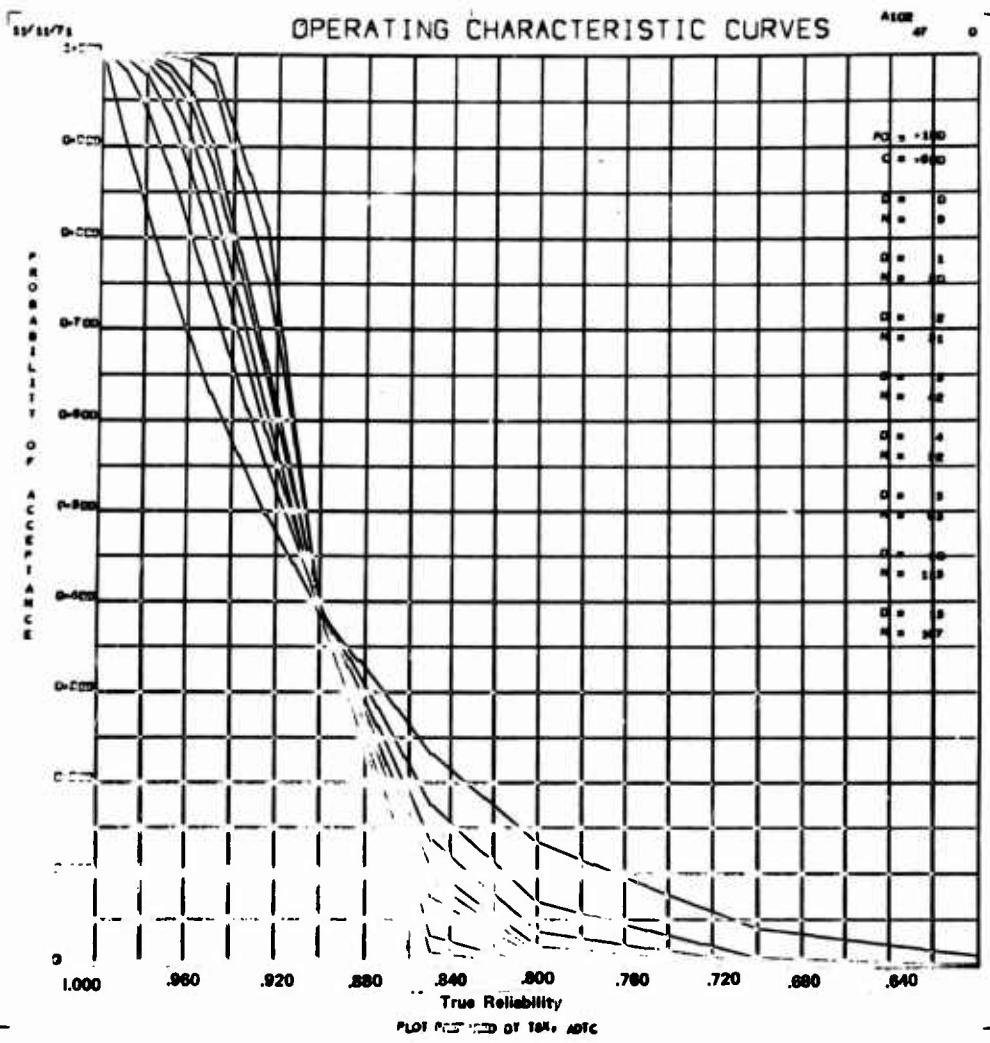


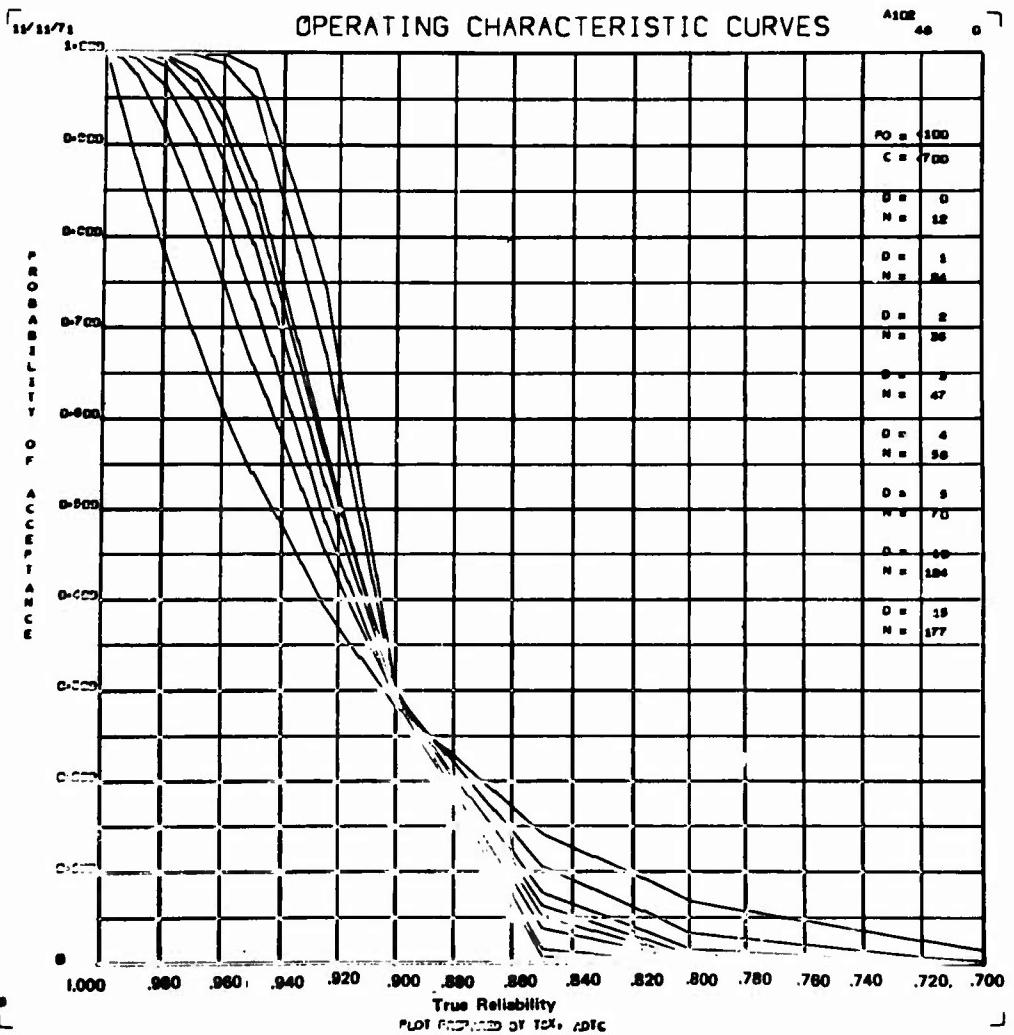


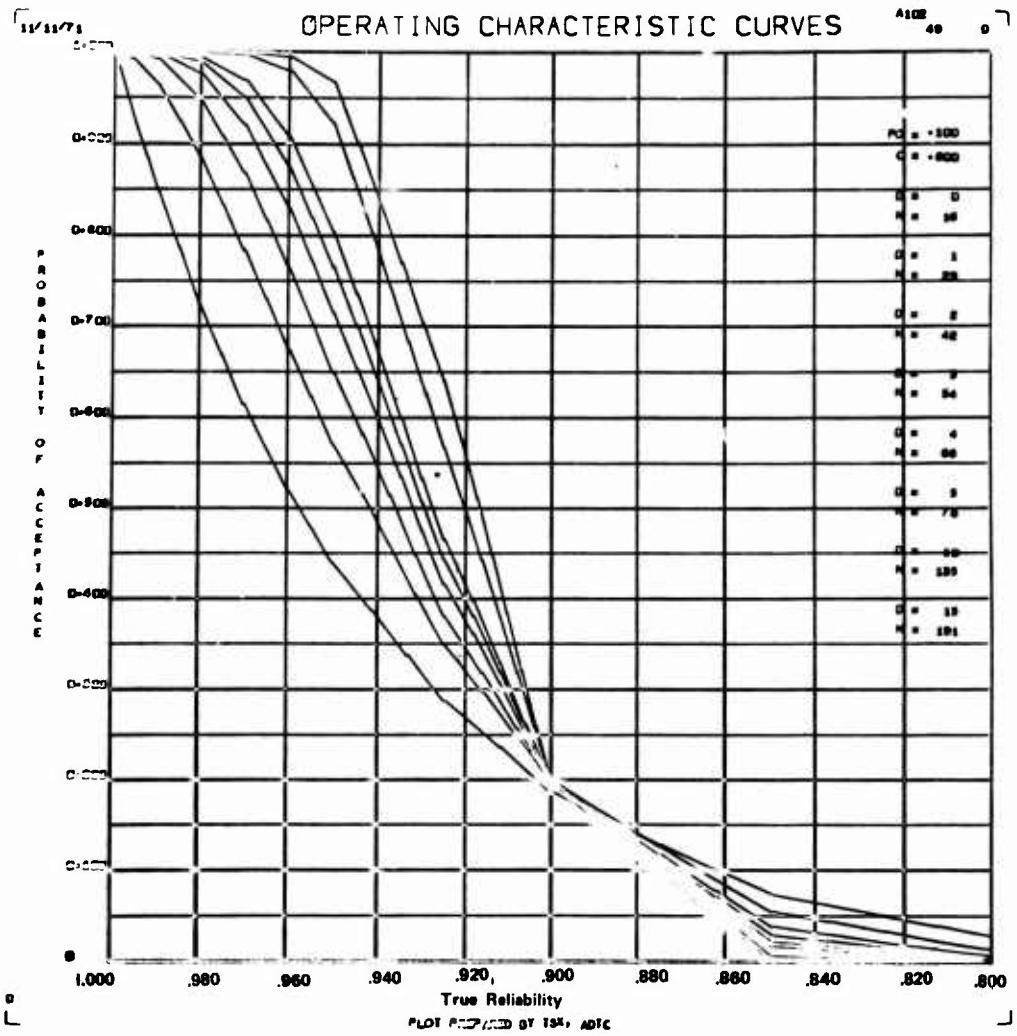


APPENDIX X
OPERATING CHARACTERISTIC
CURVES ($p_0 = .100$)





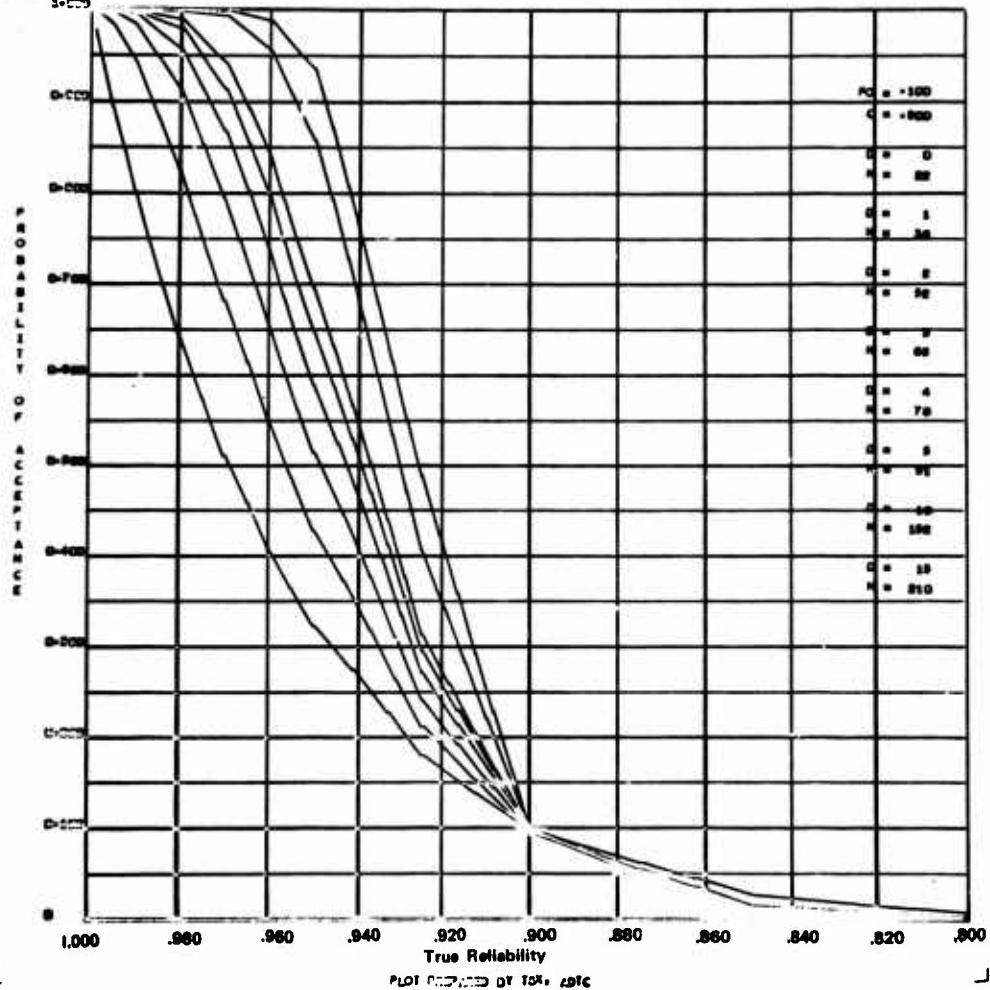




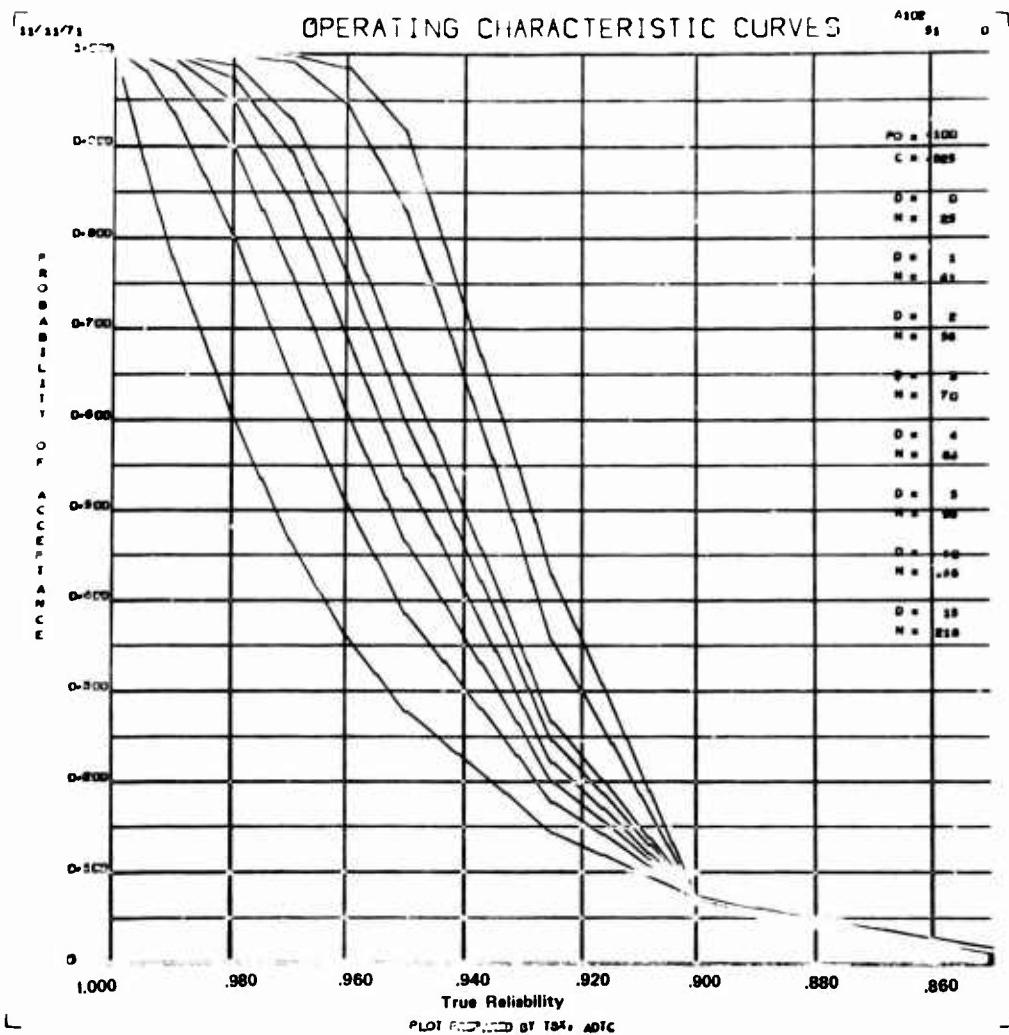
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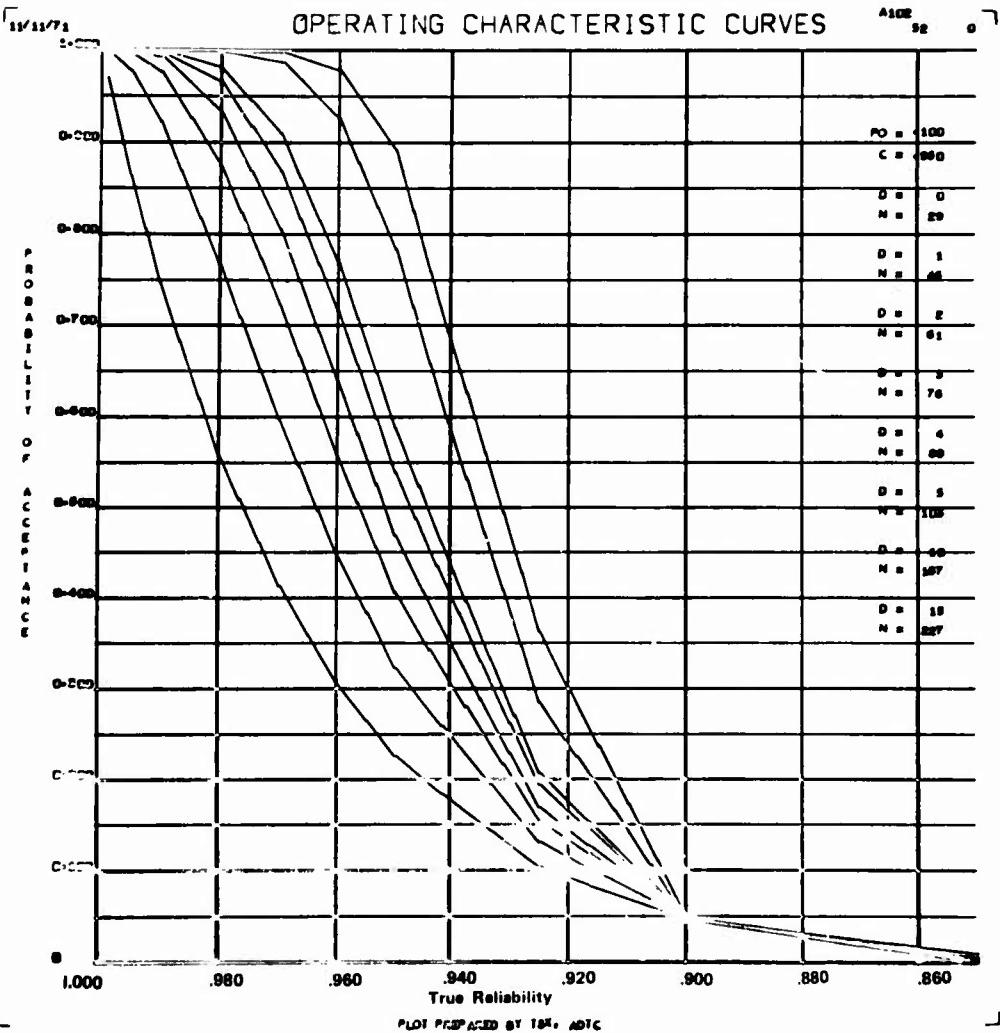
OPERATING CHARACTERISTIC CURVES

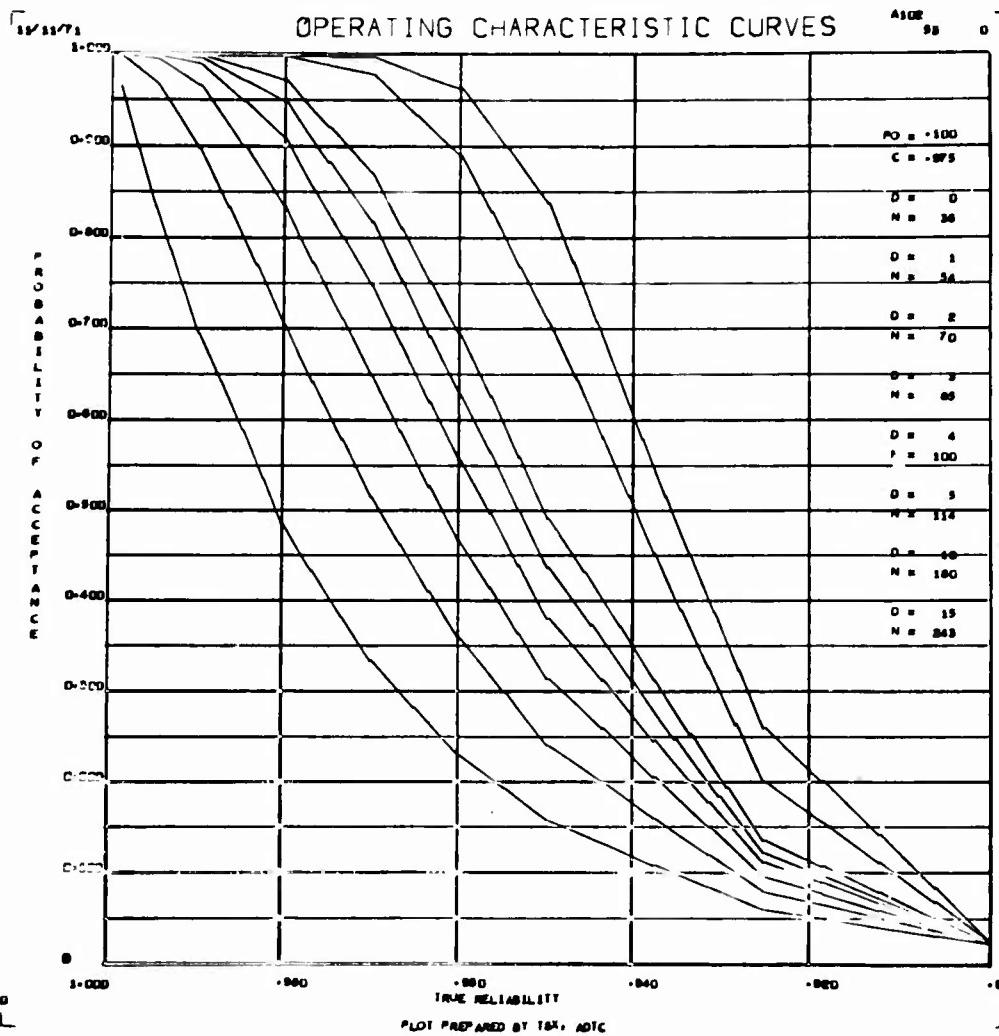
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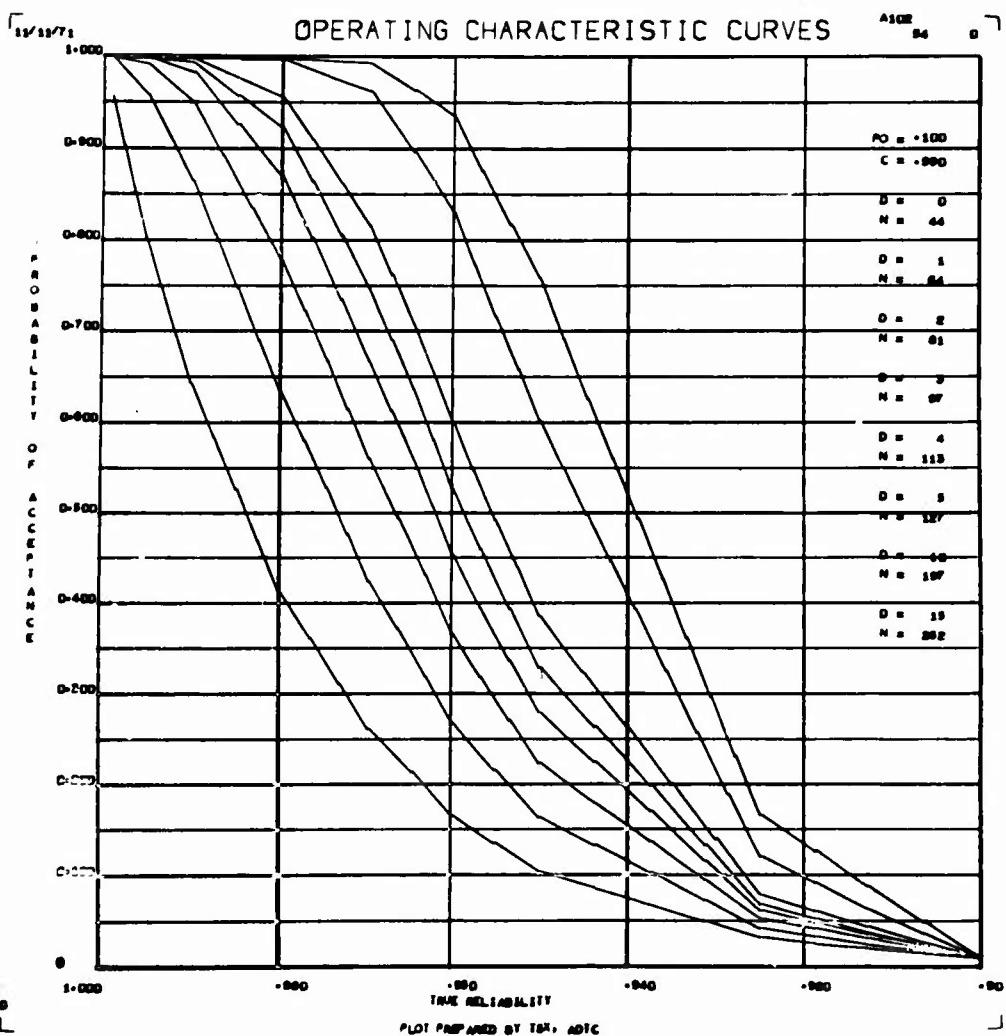


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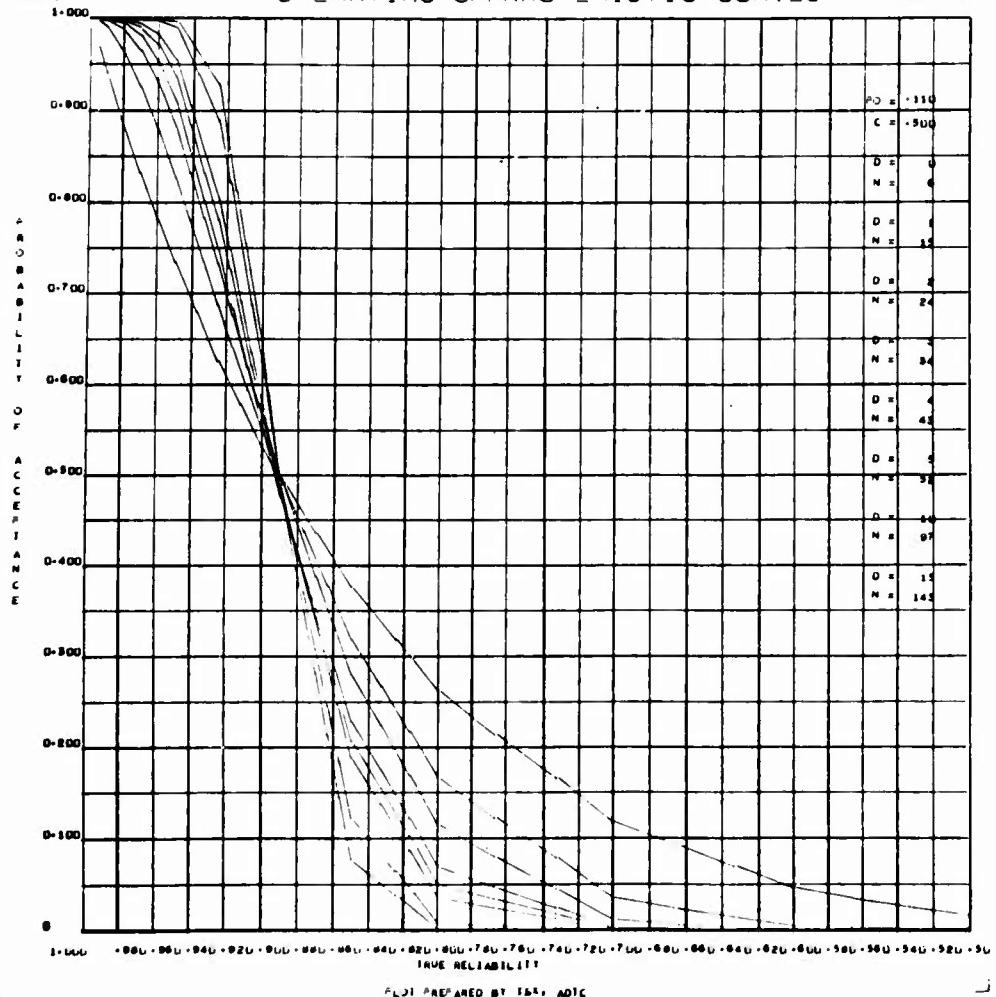
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OPERATING CHARACTERISTIC
CURVES ($p_0 = .110$)

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OPERATING CHARACTERISTIC CURVES

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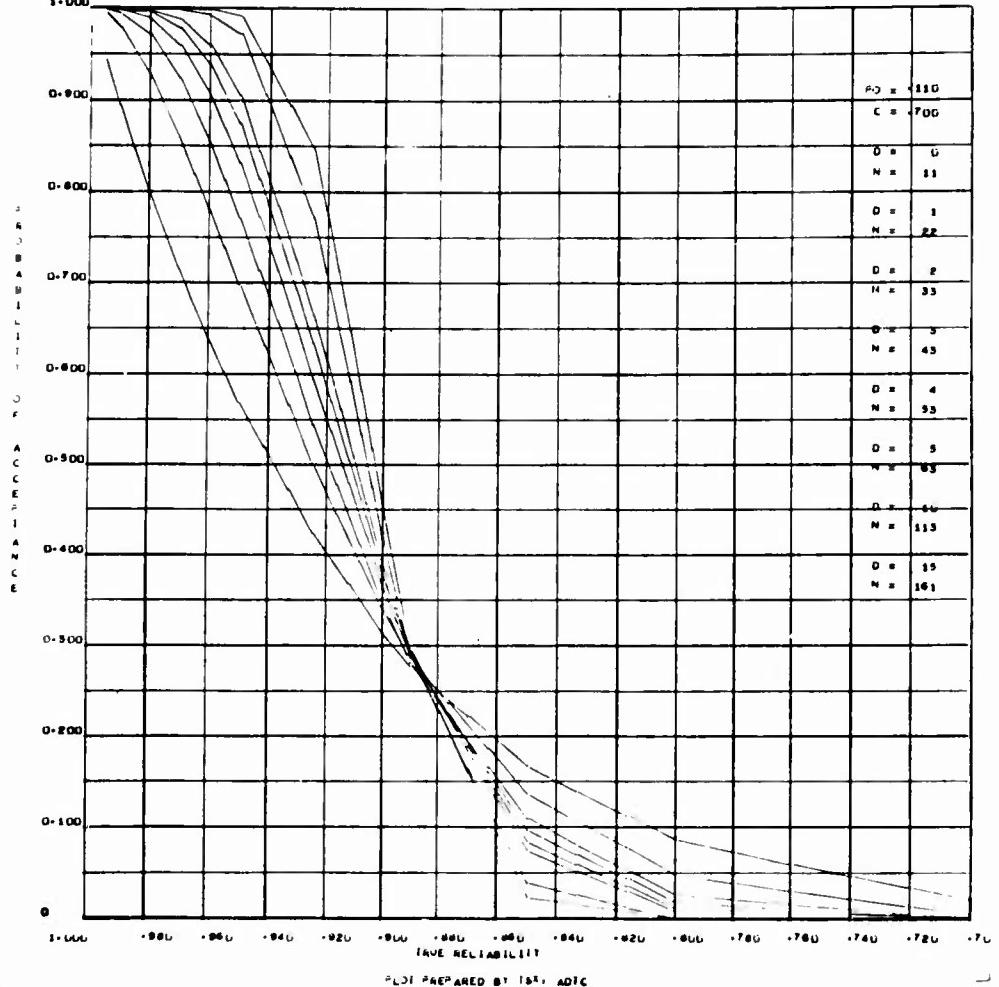
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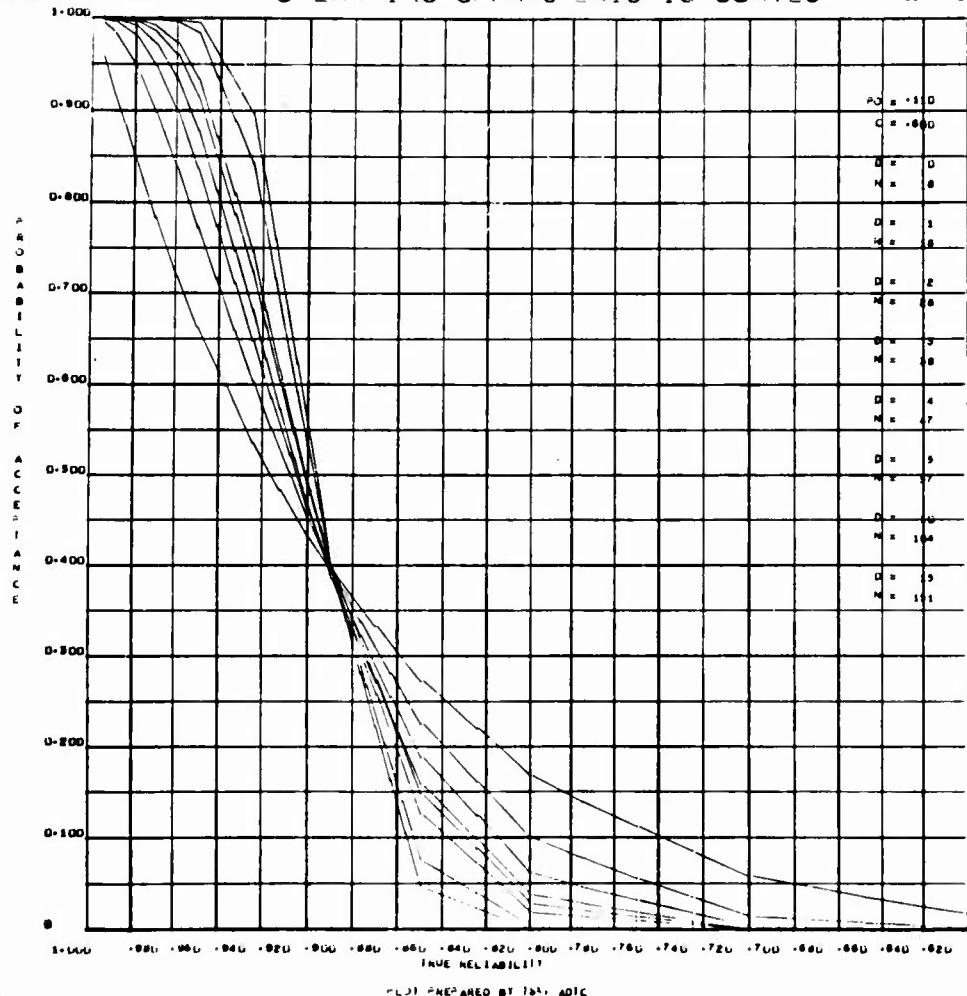
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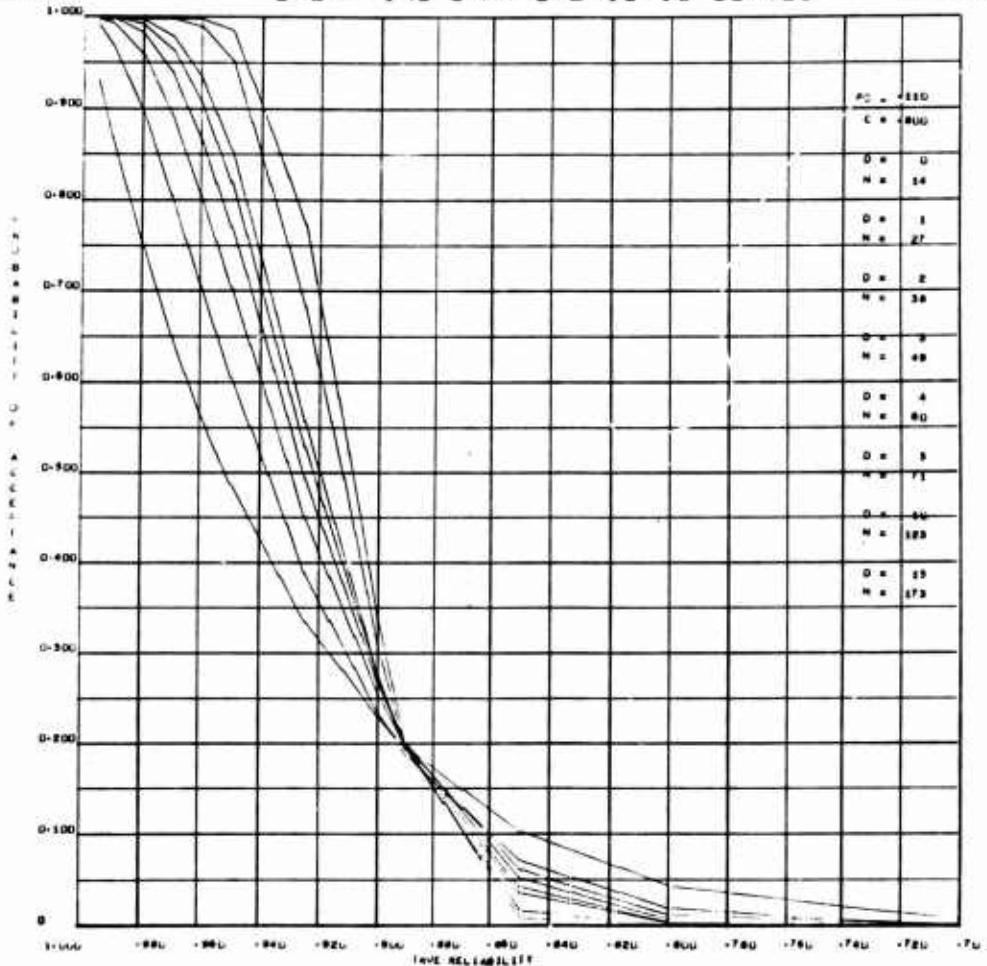


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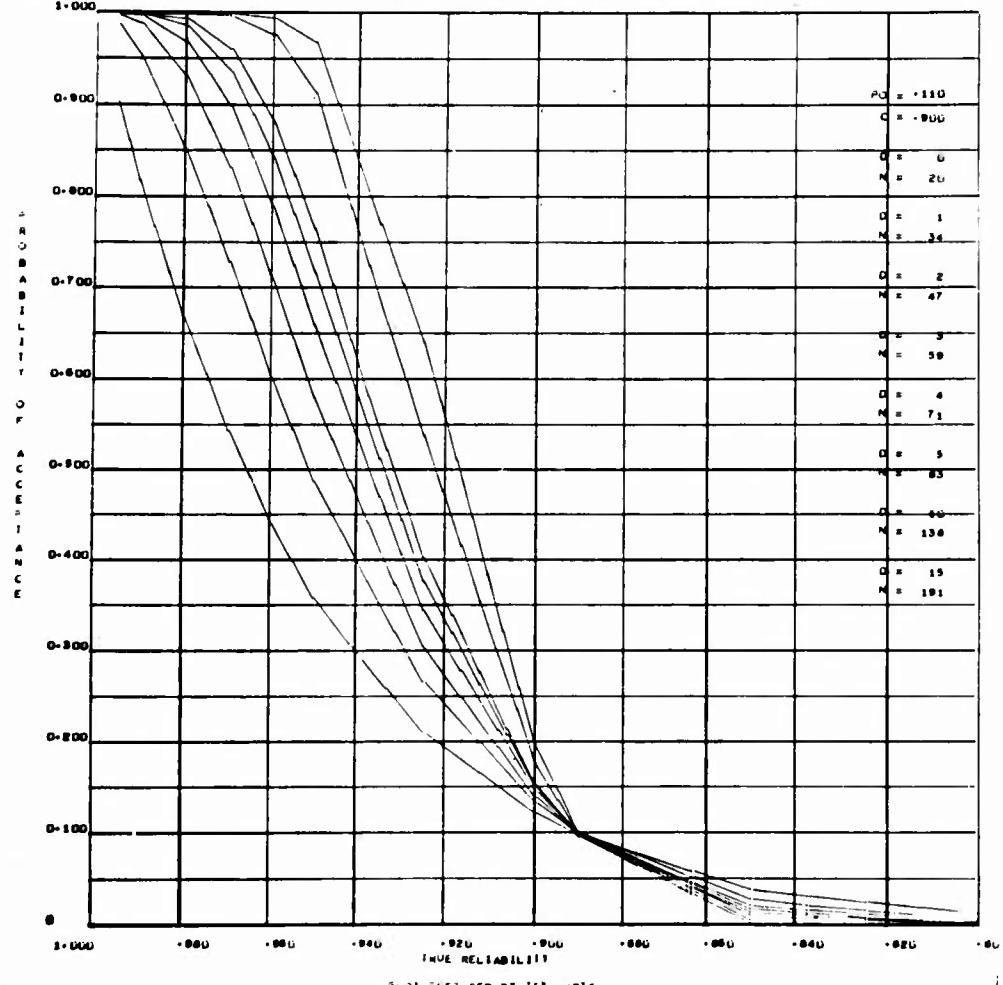
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OPERATING CHARACTERISTIC CURVES

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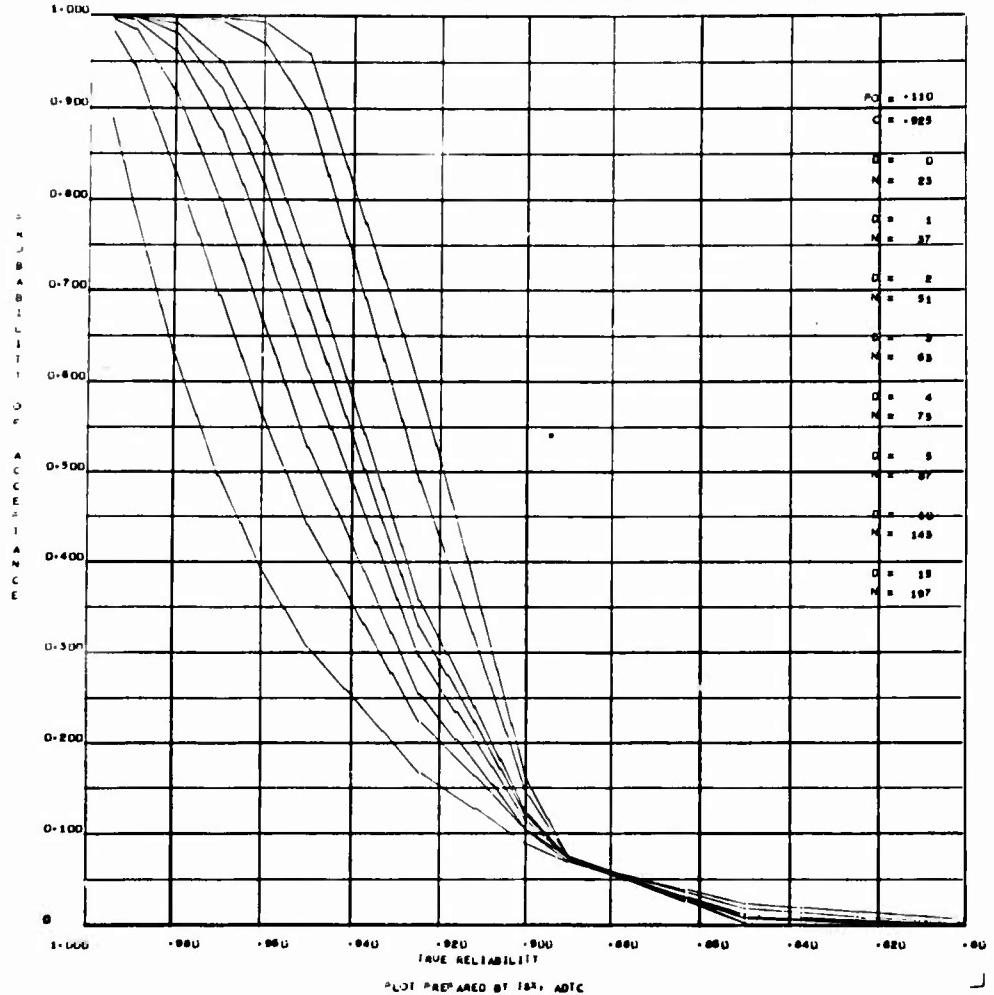


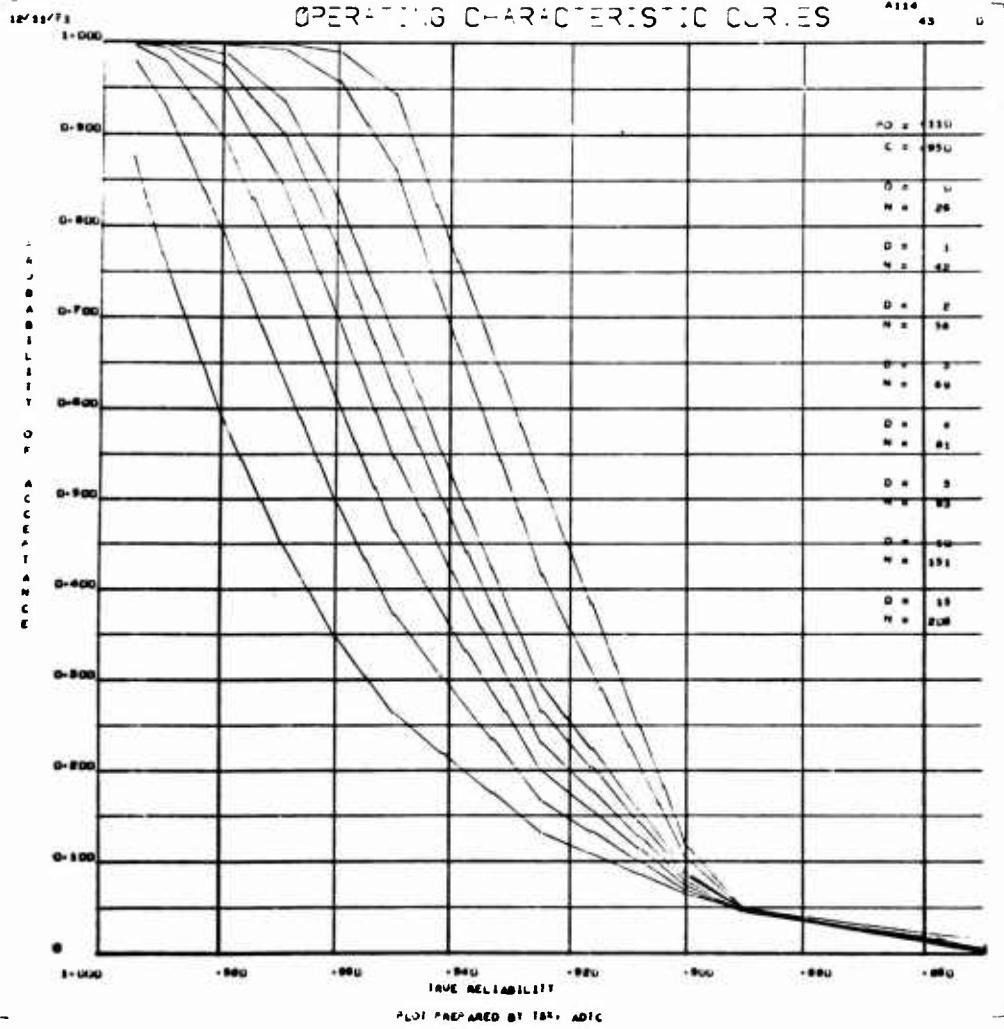
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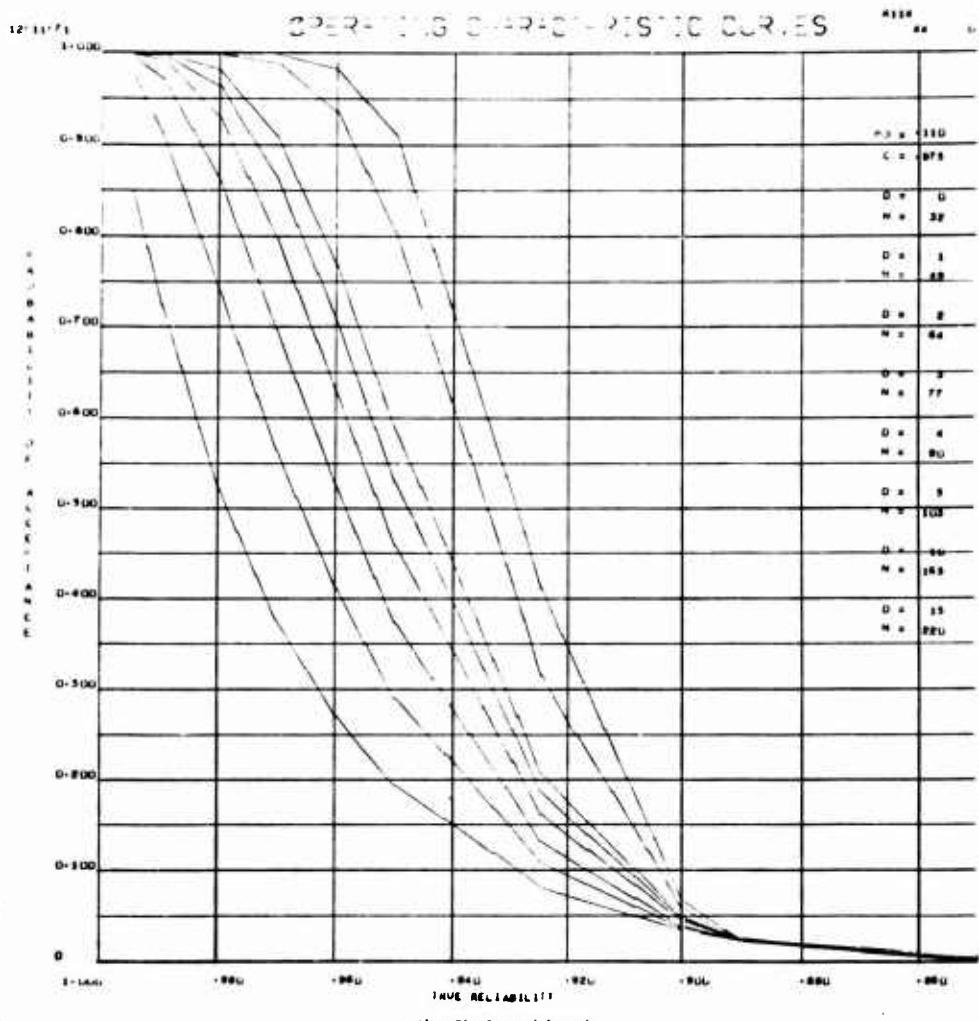
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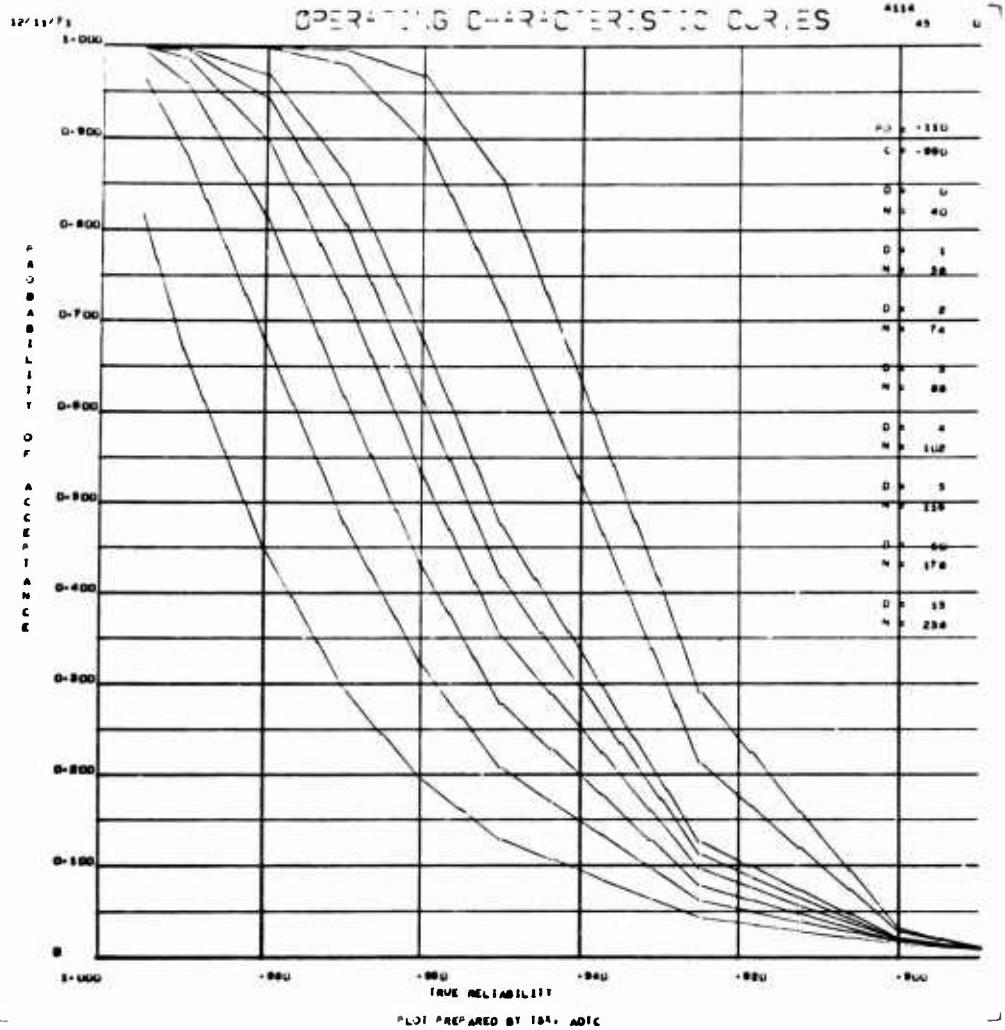
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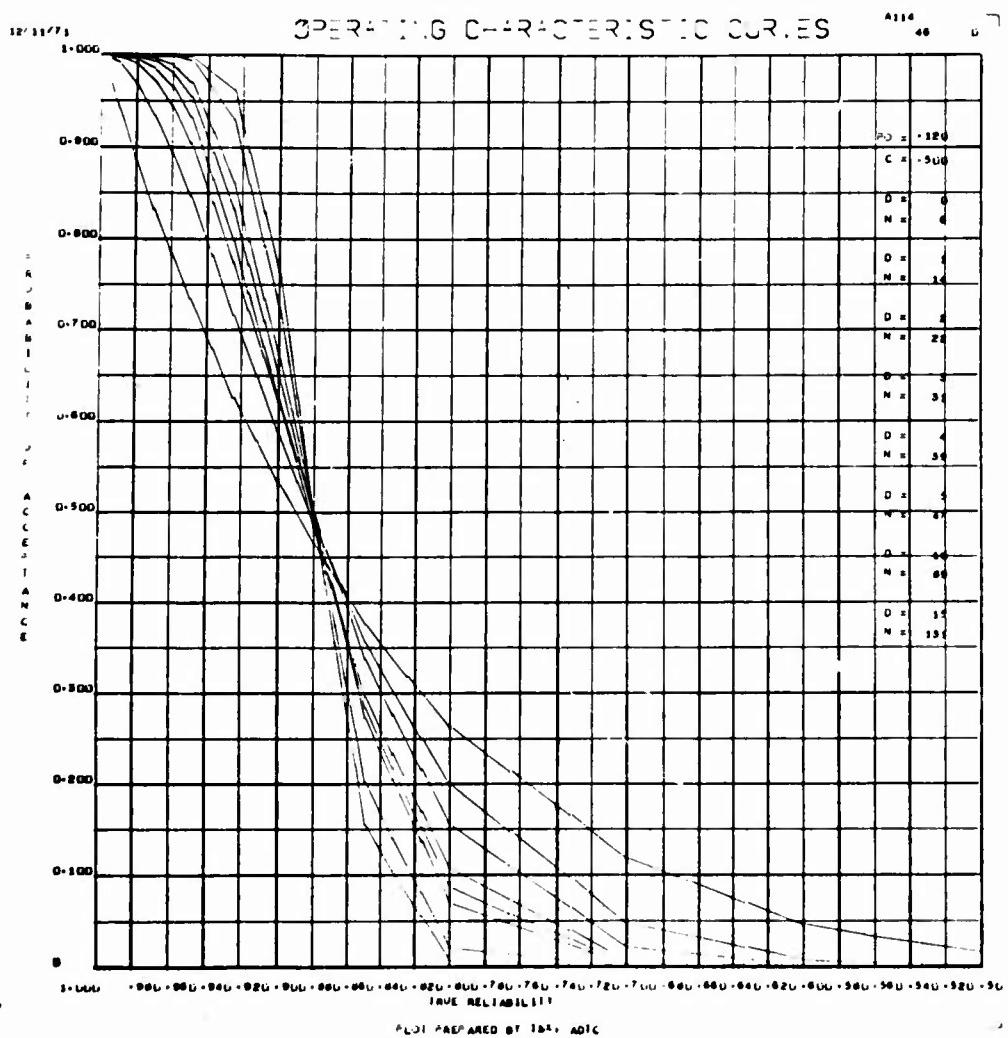


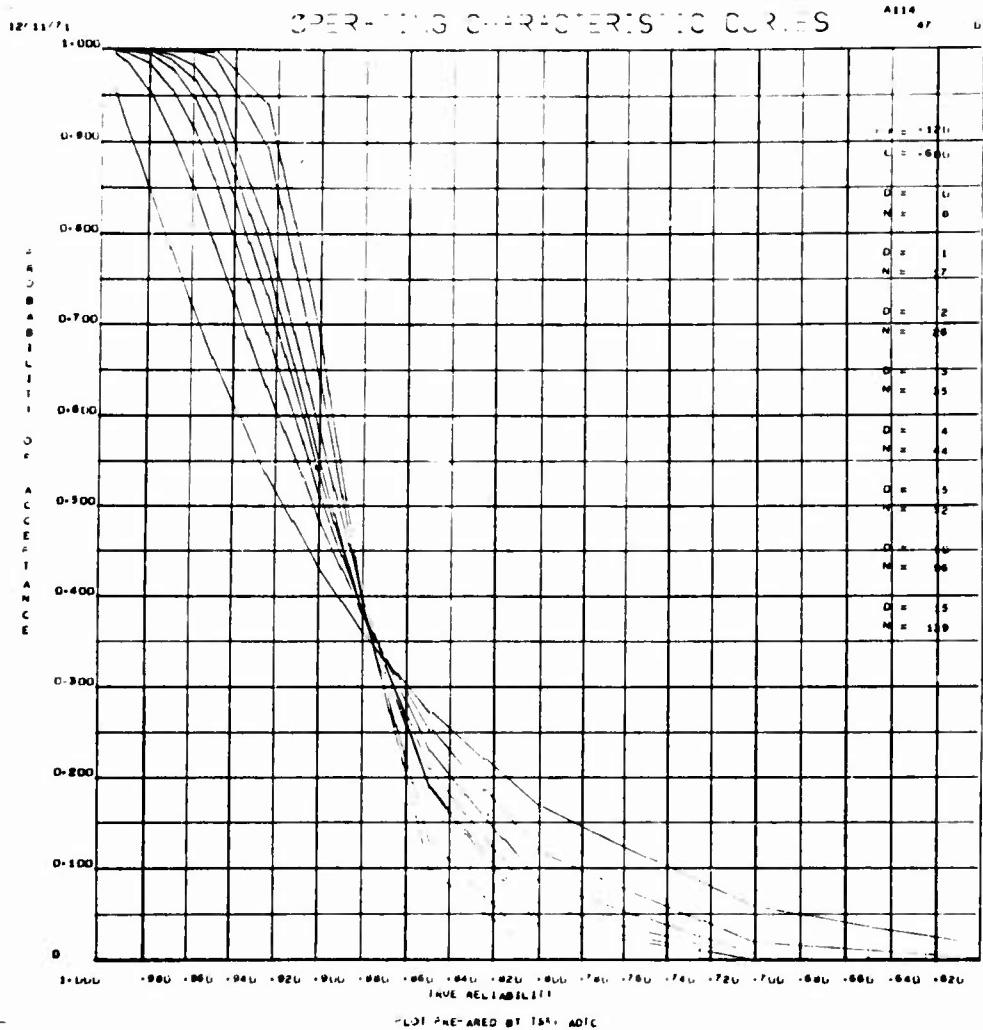


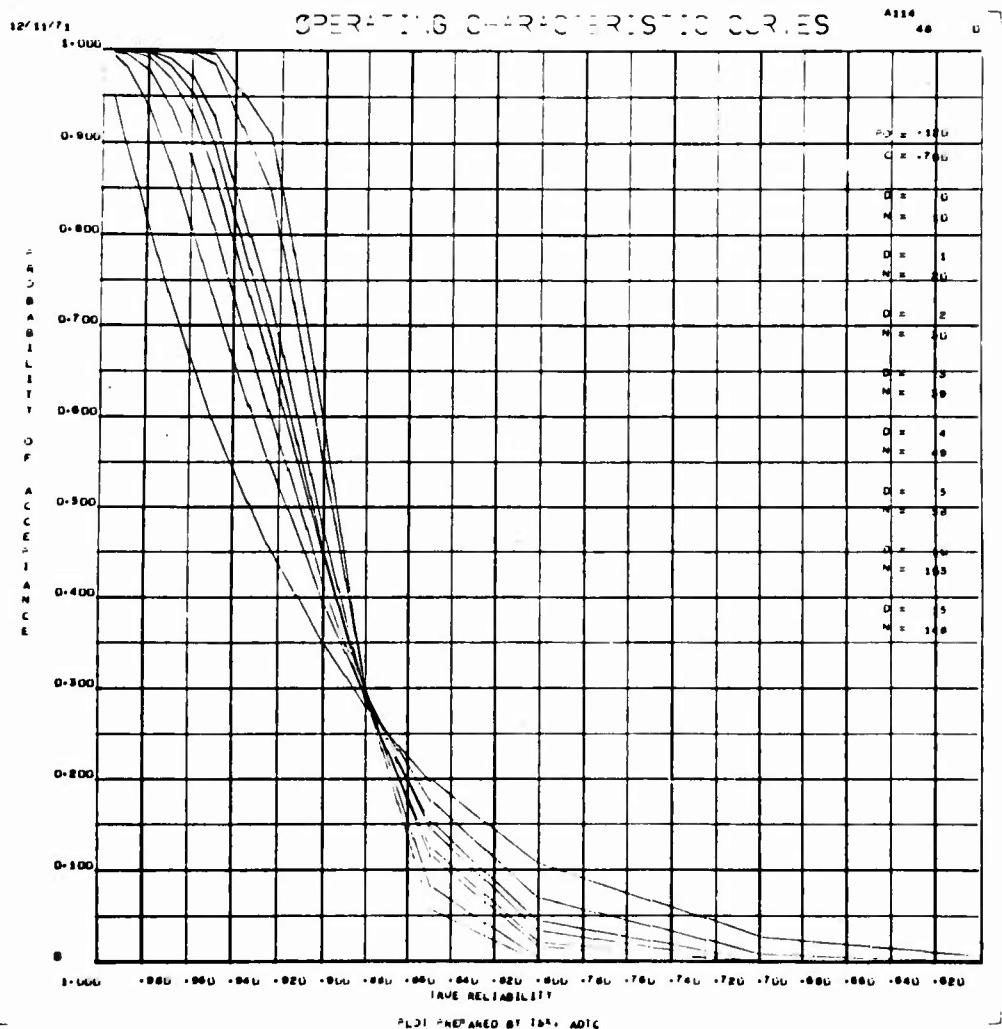


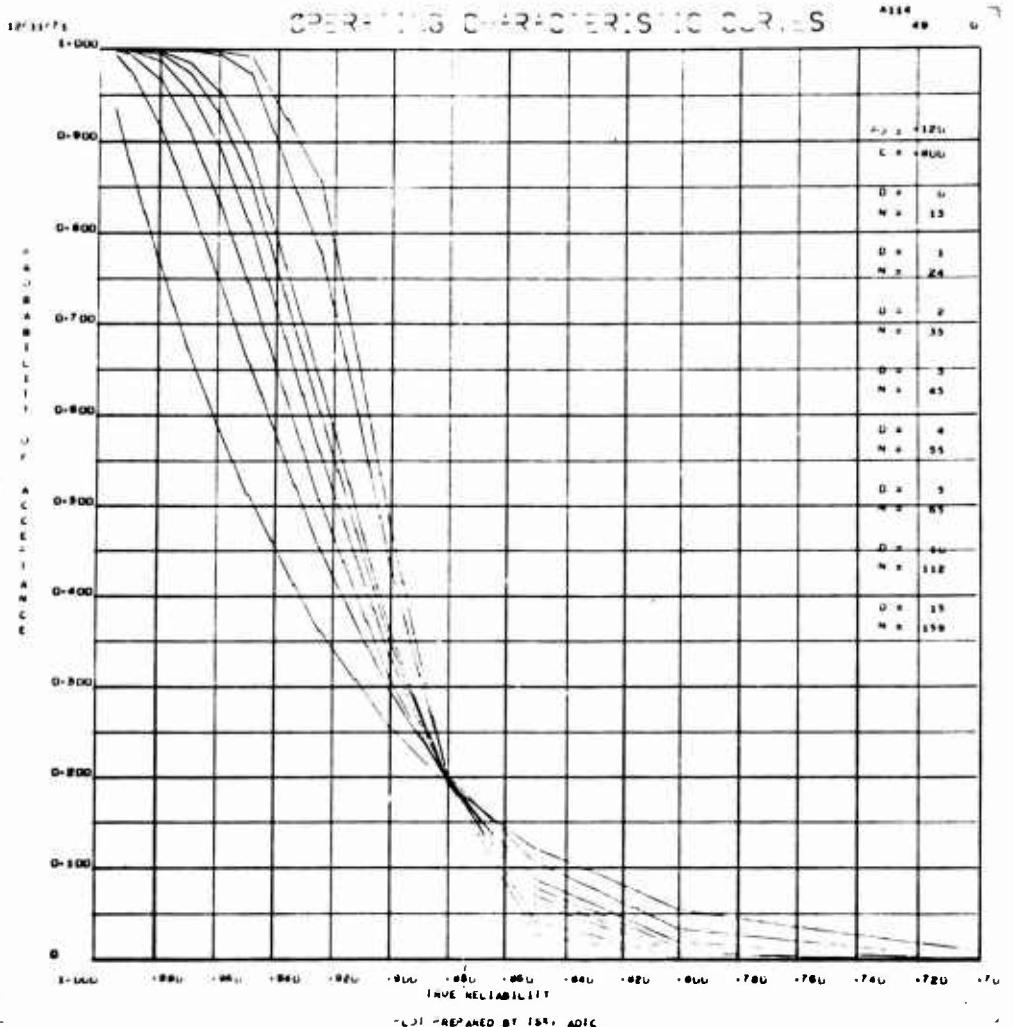


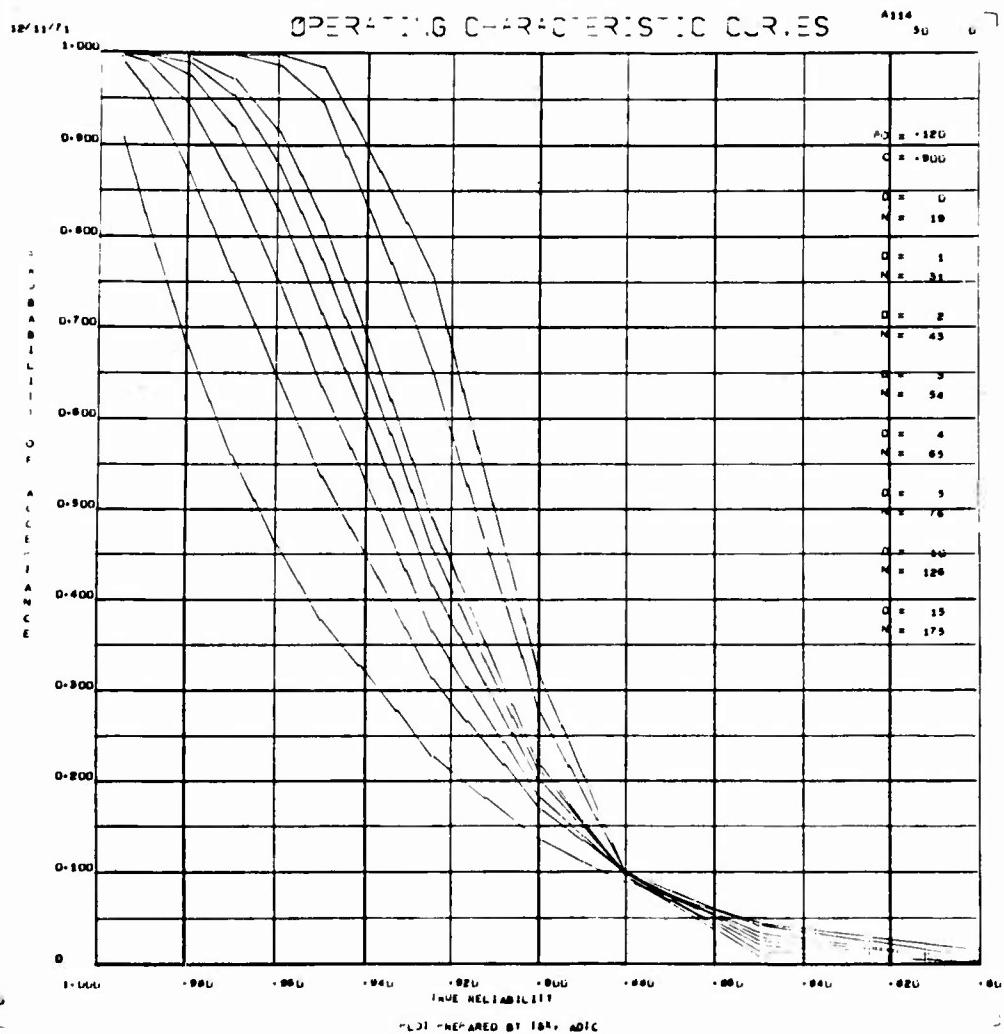
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OPERATING CHARACTERISTIC
CURVES ($p_0 = .120$)

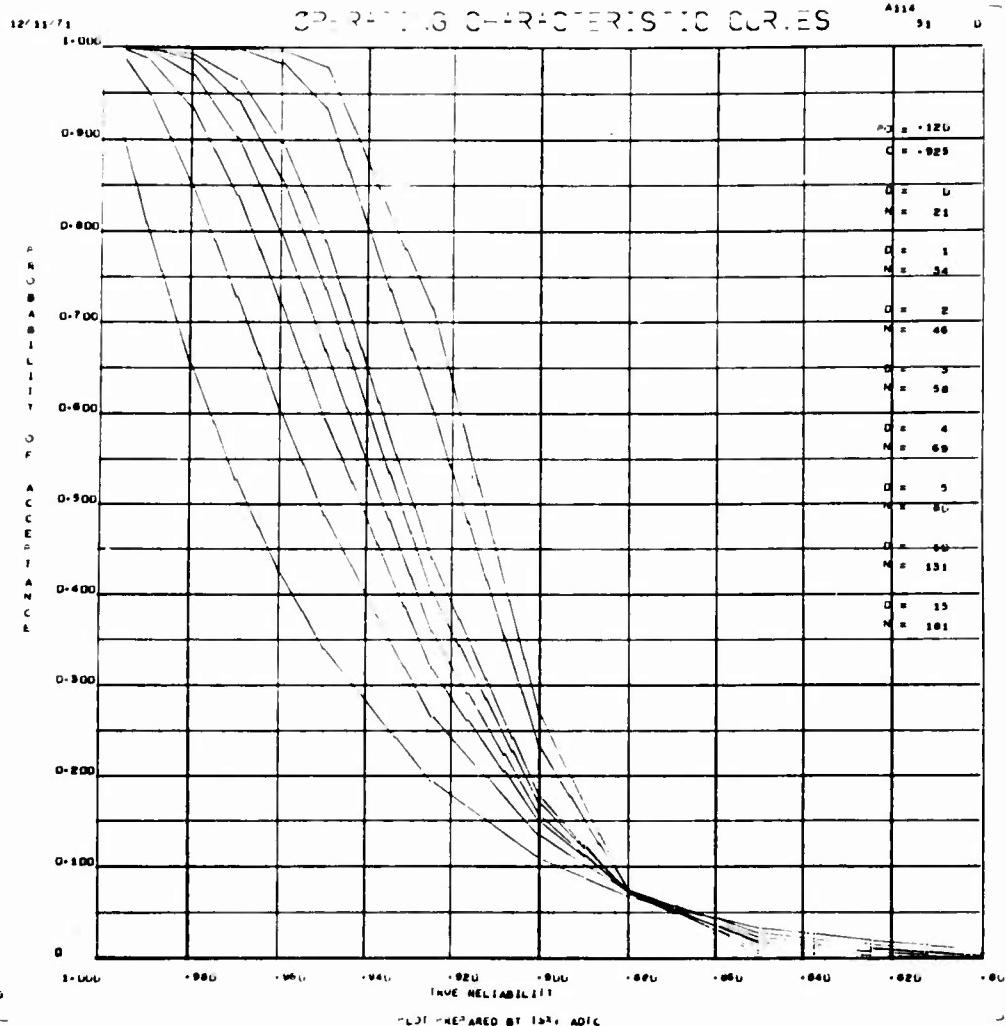


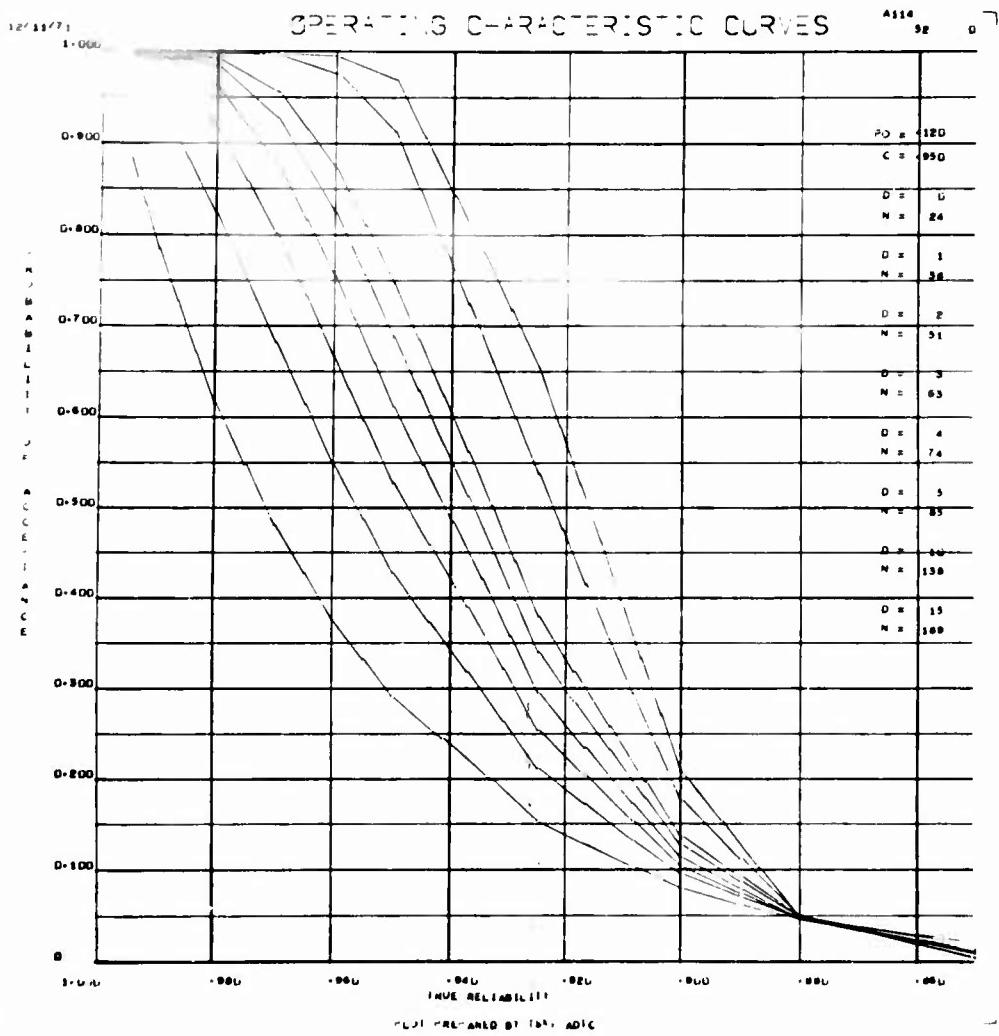


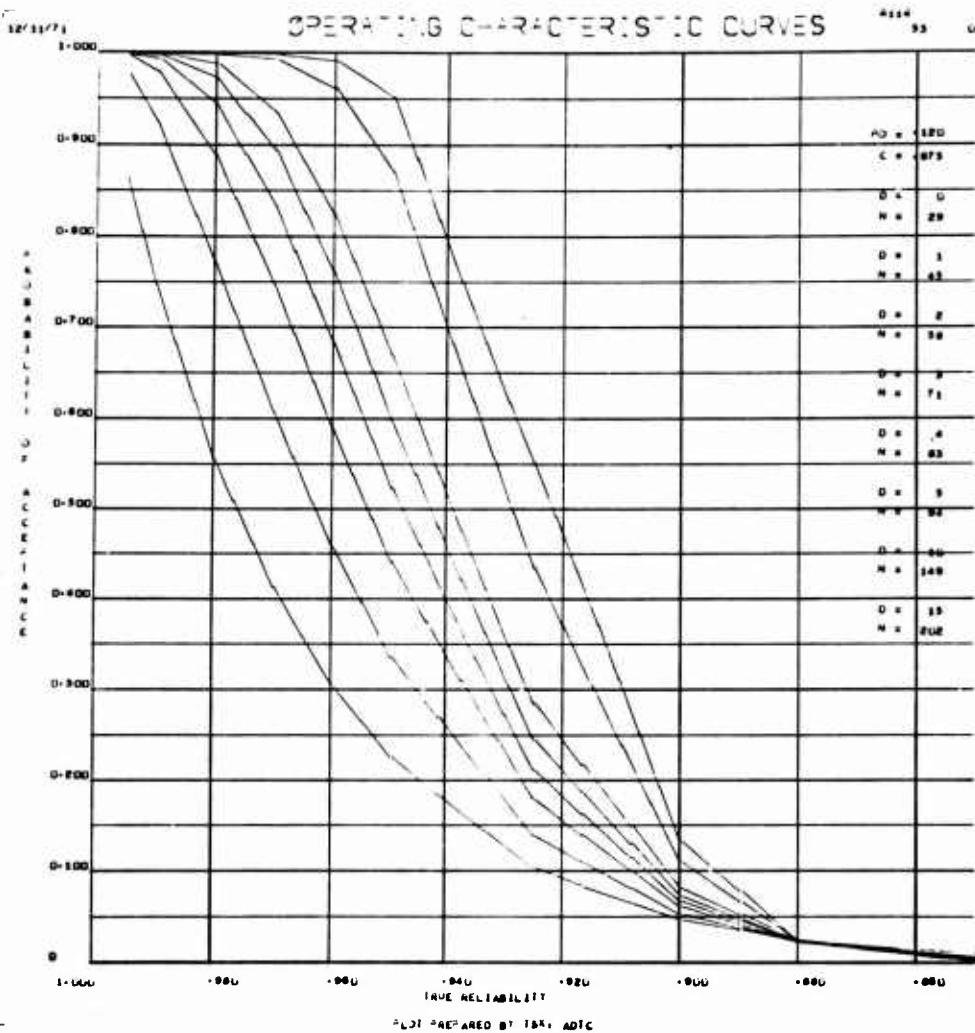


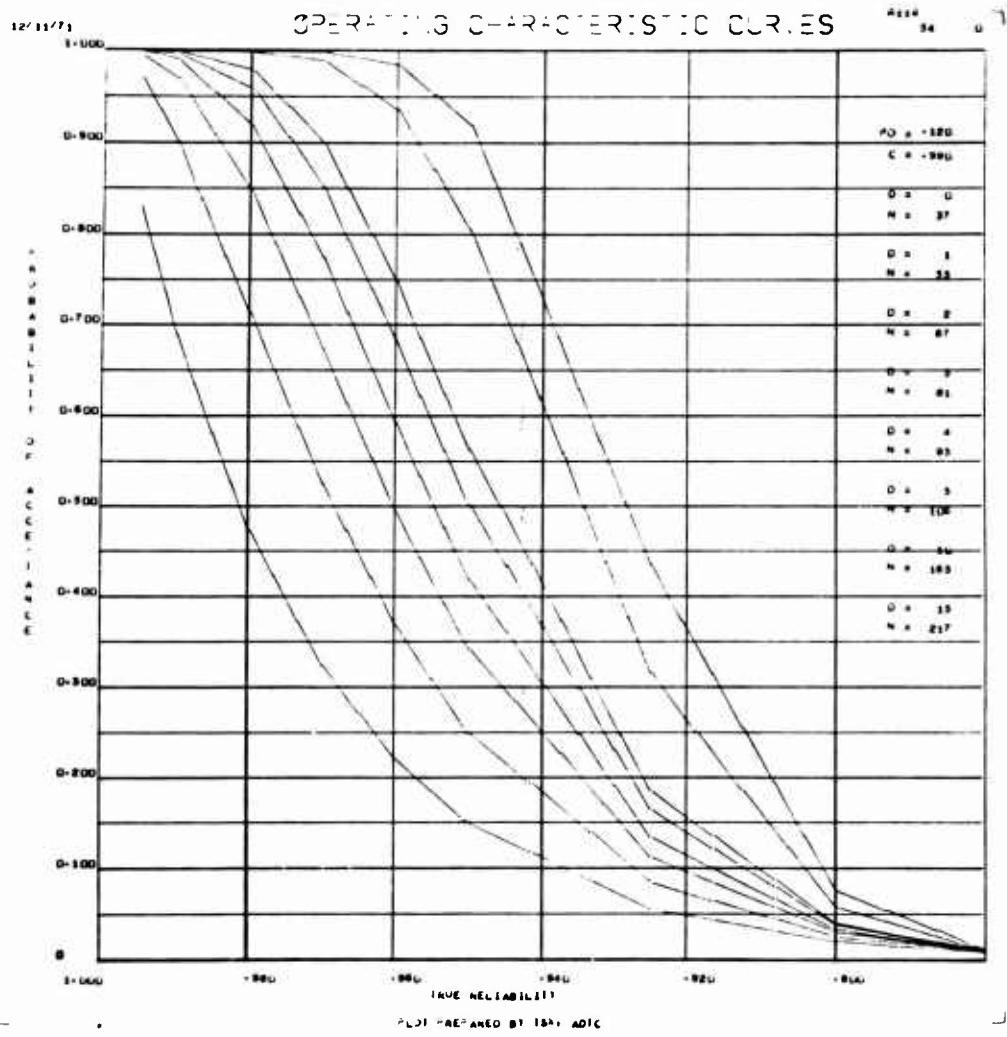




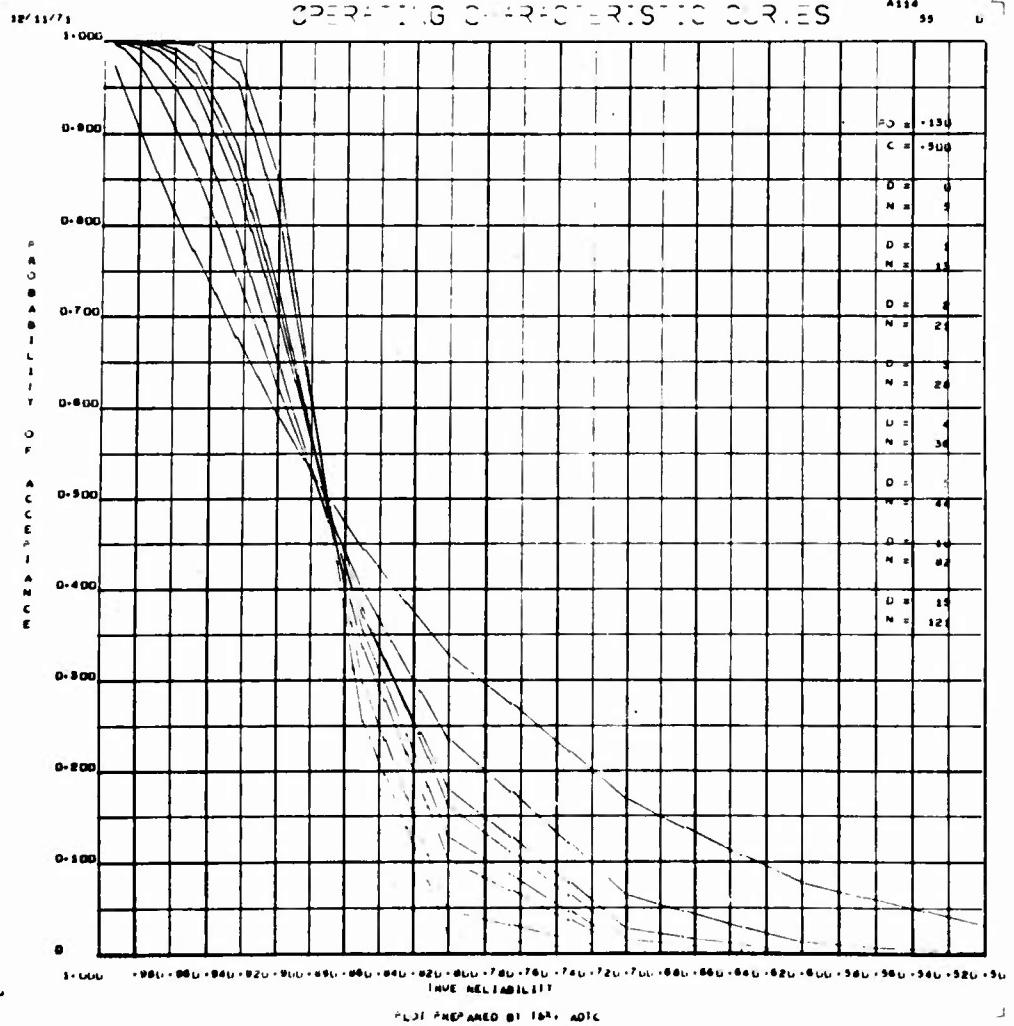








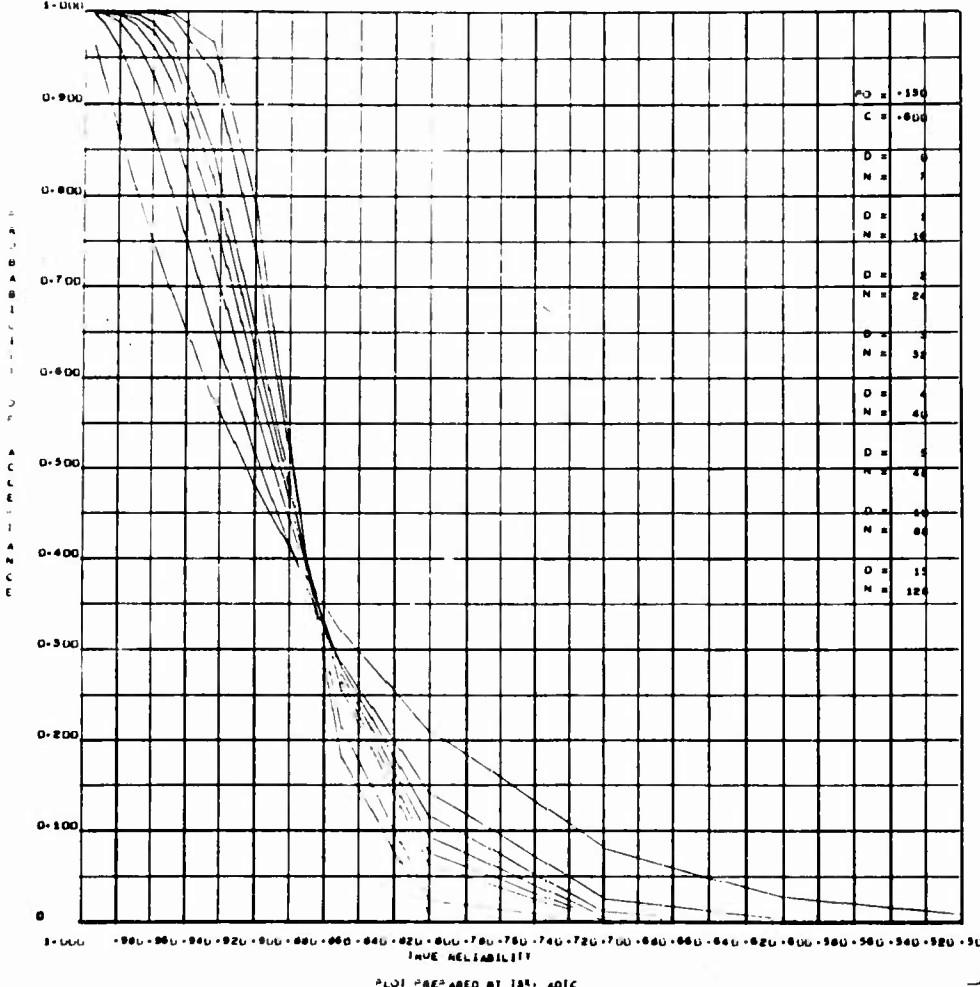
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OPERATING CHARACTERISTIC
CURVES ($p_0 = .130$)

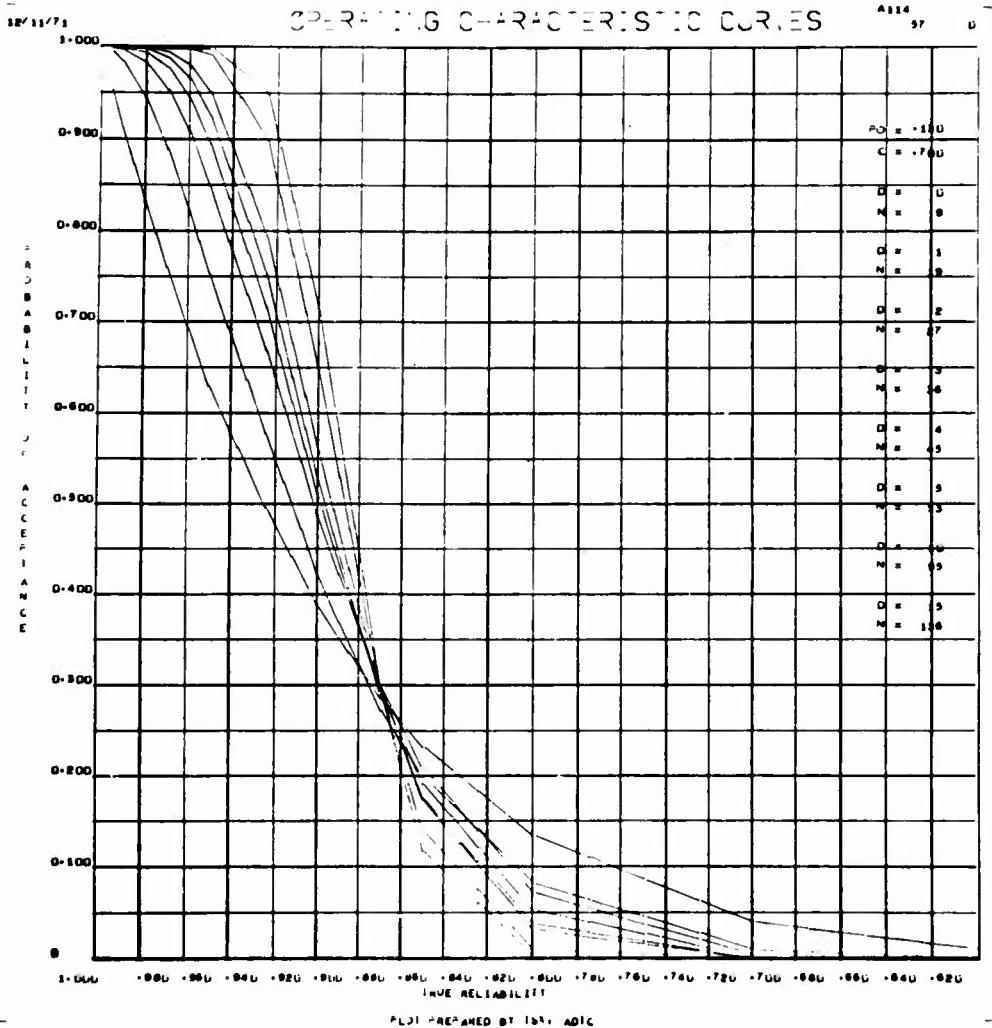


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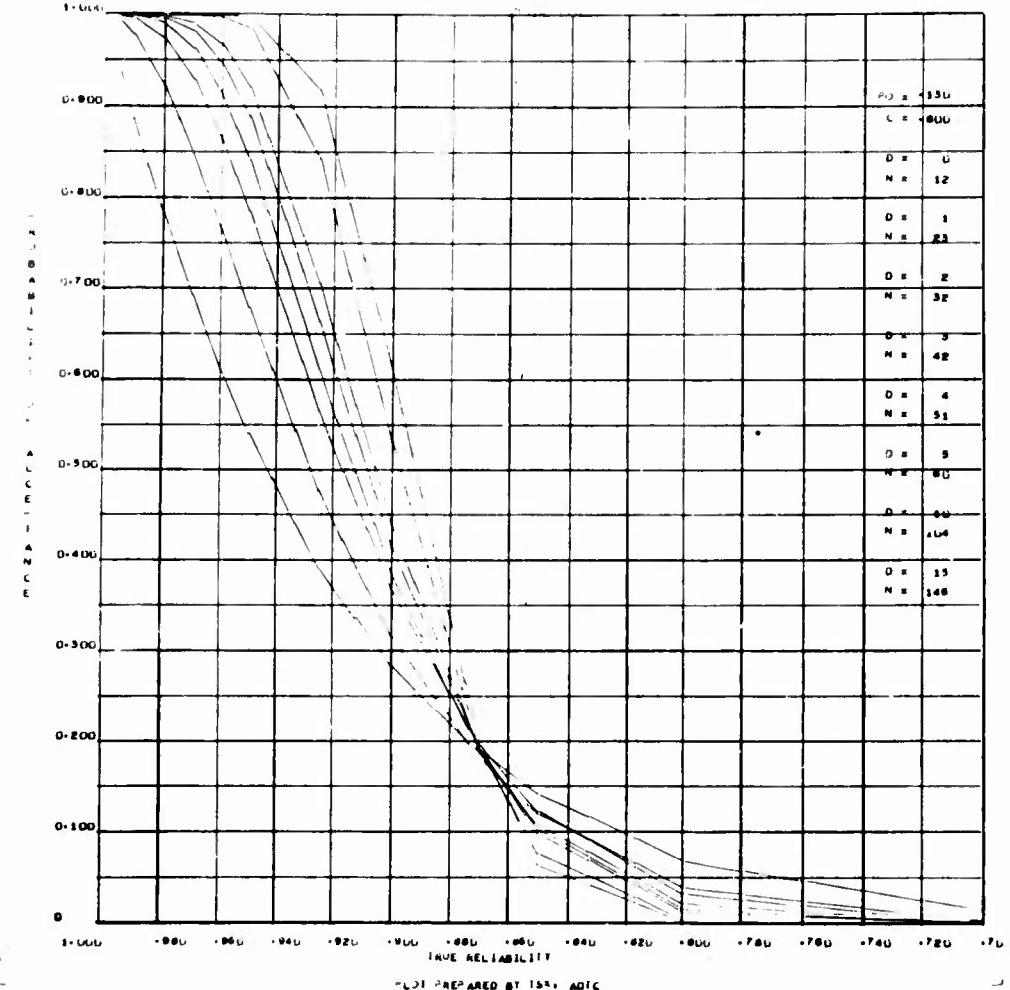
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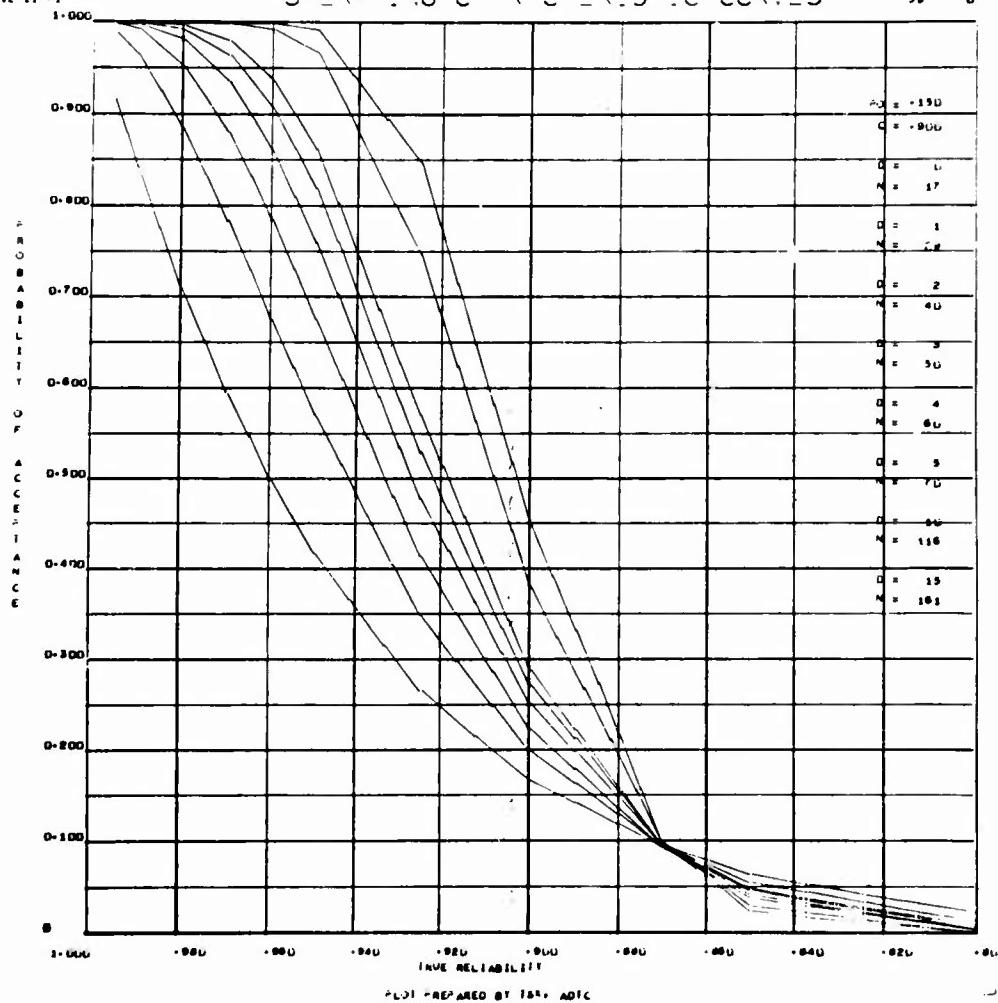


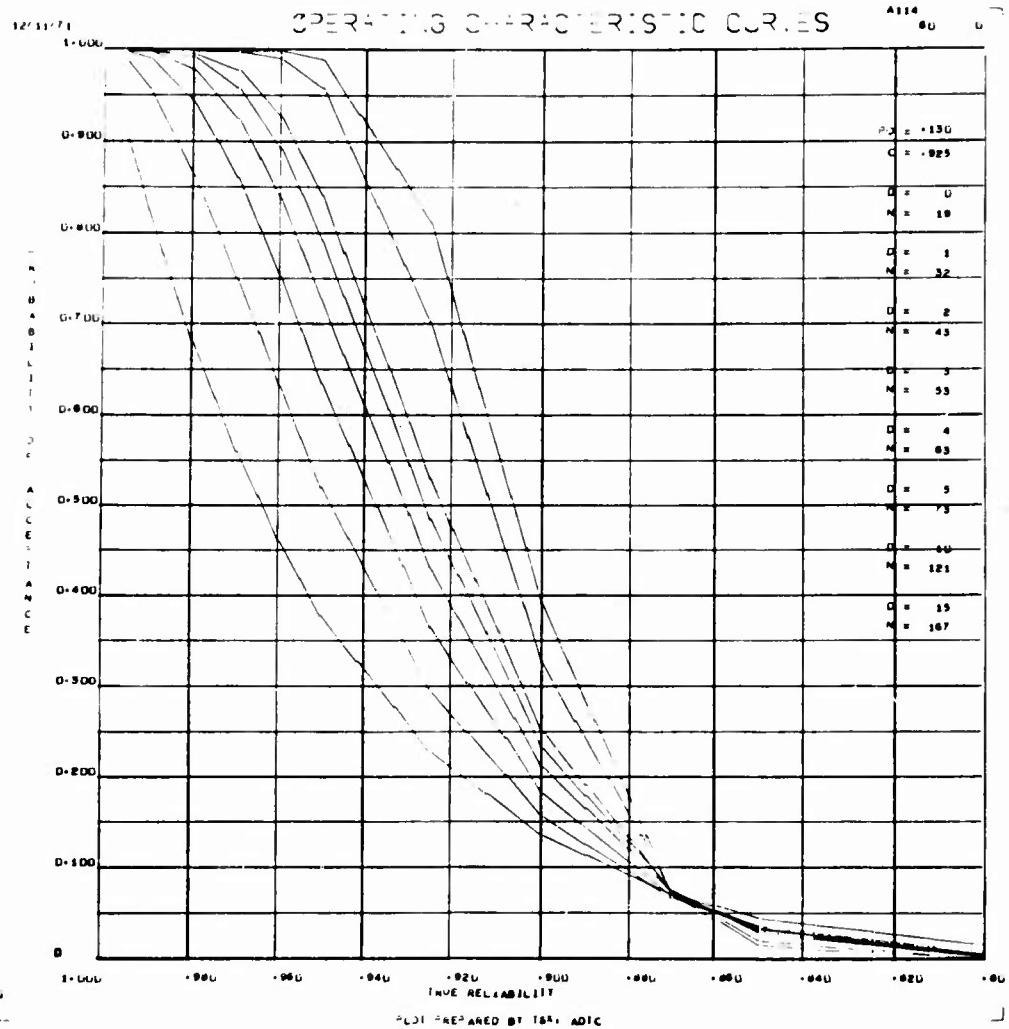
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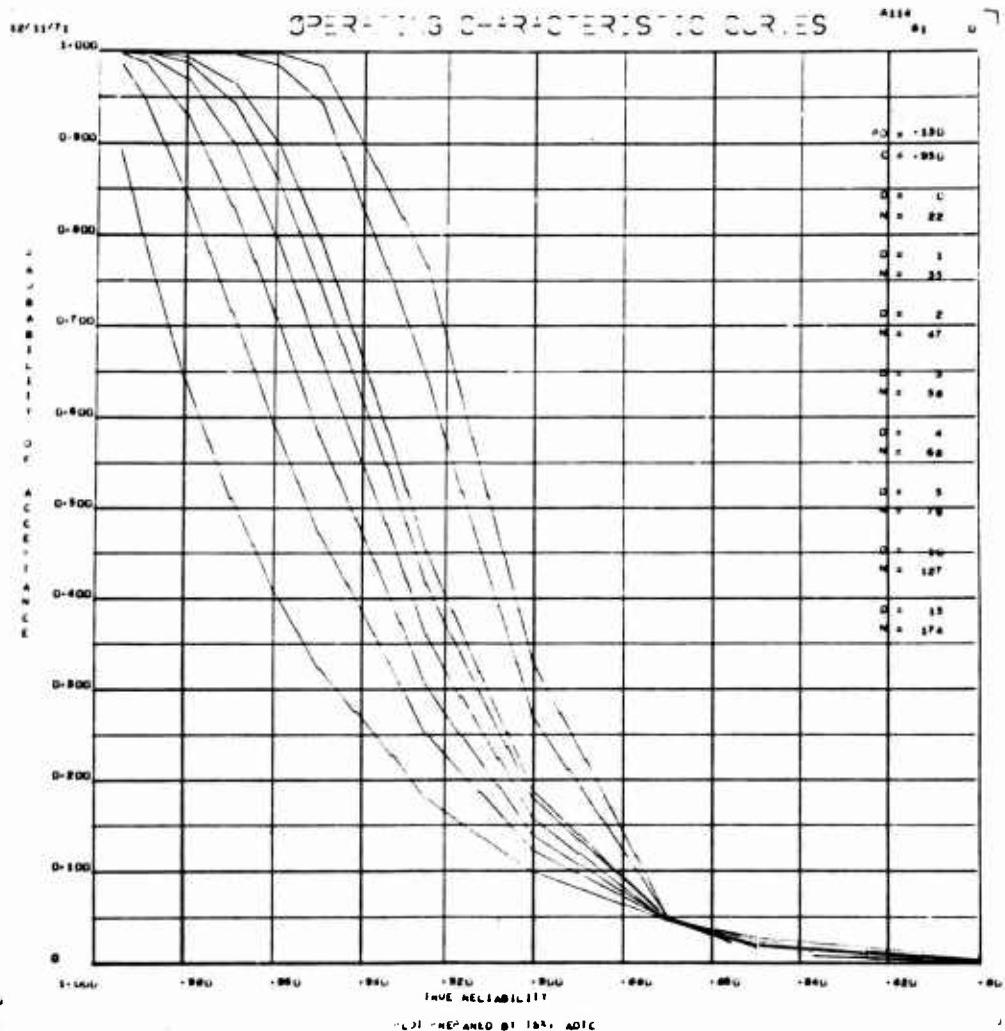
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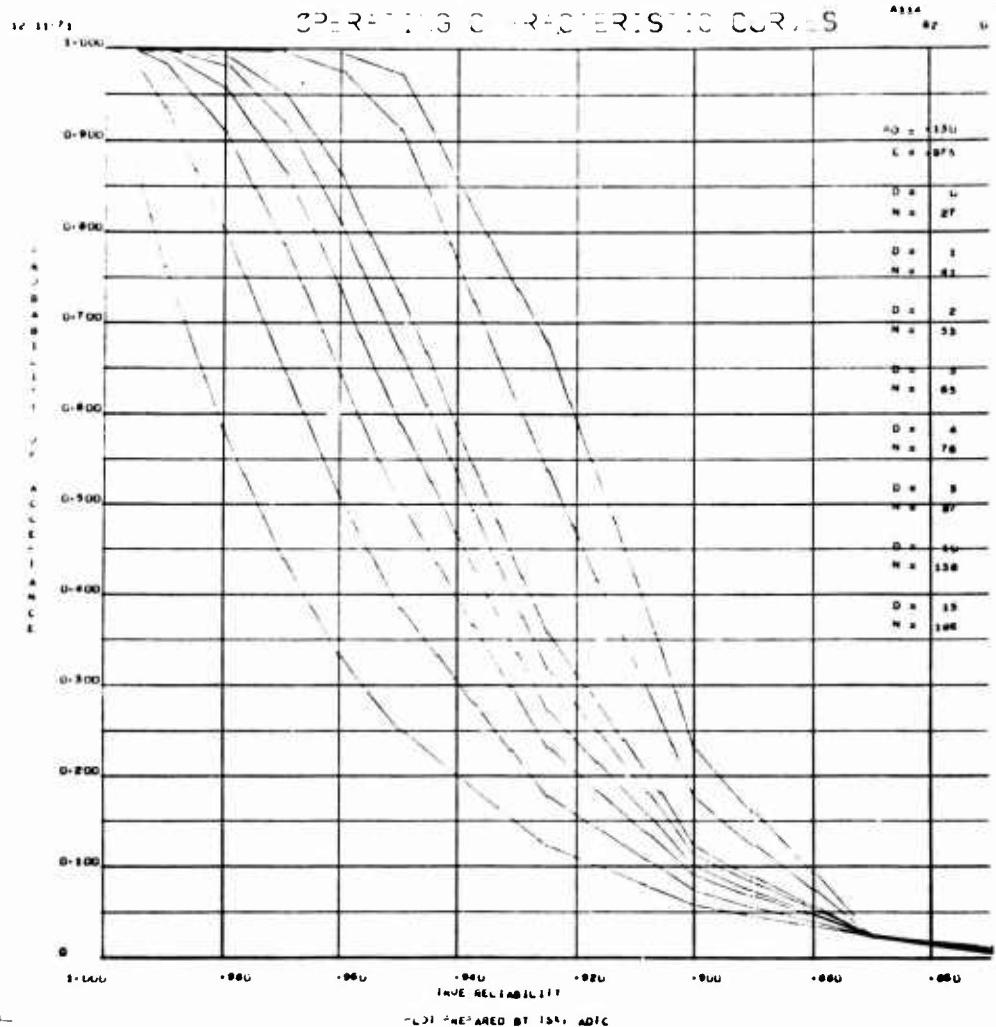
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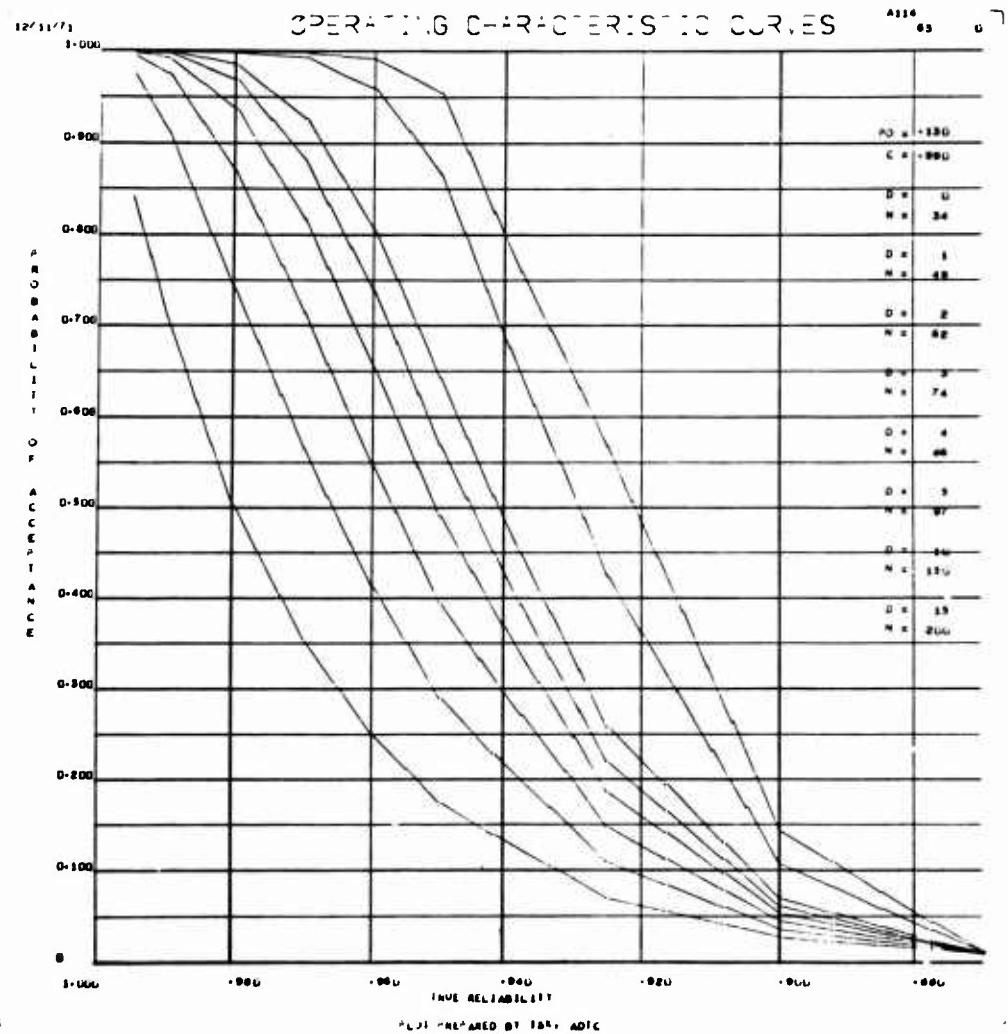
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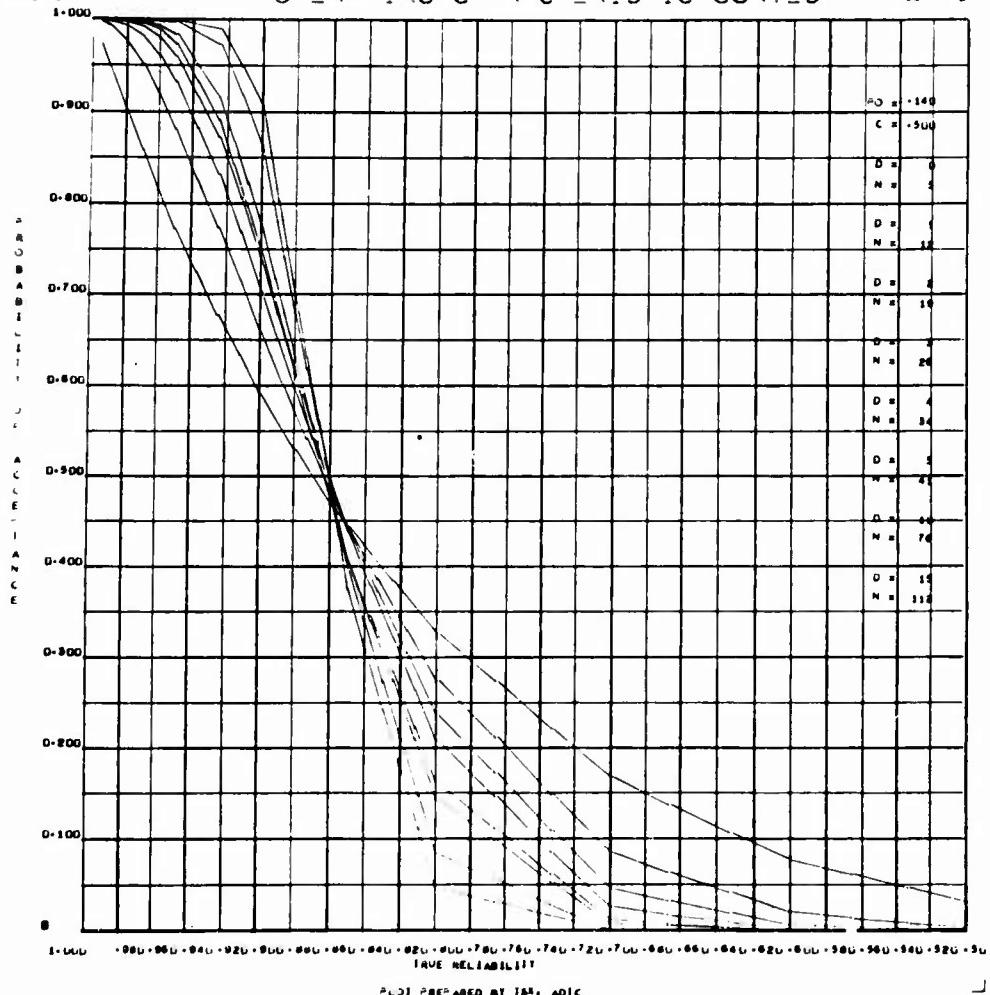


APPENDIX XIV
OPERATING CHARACTERISTIC
CURVES ($p_0 = .140$)

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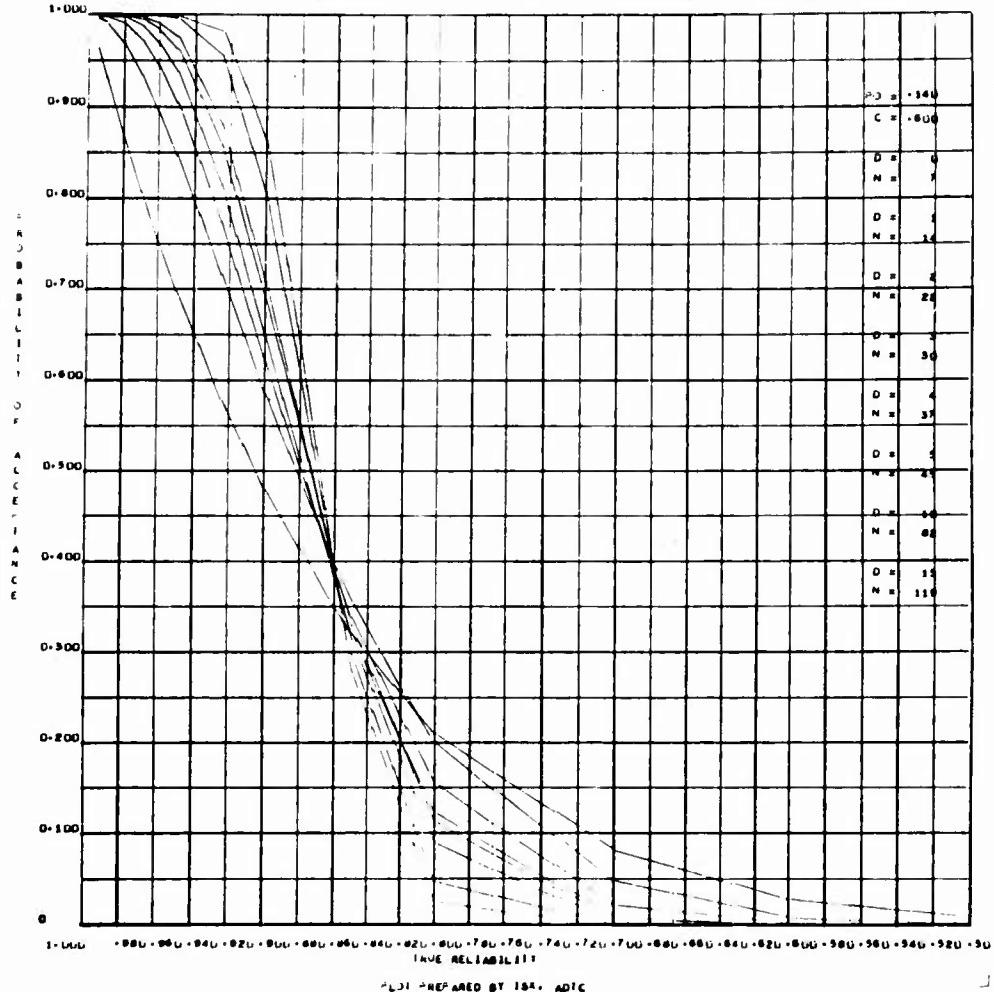
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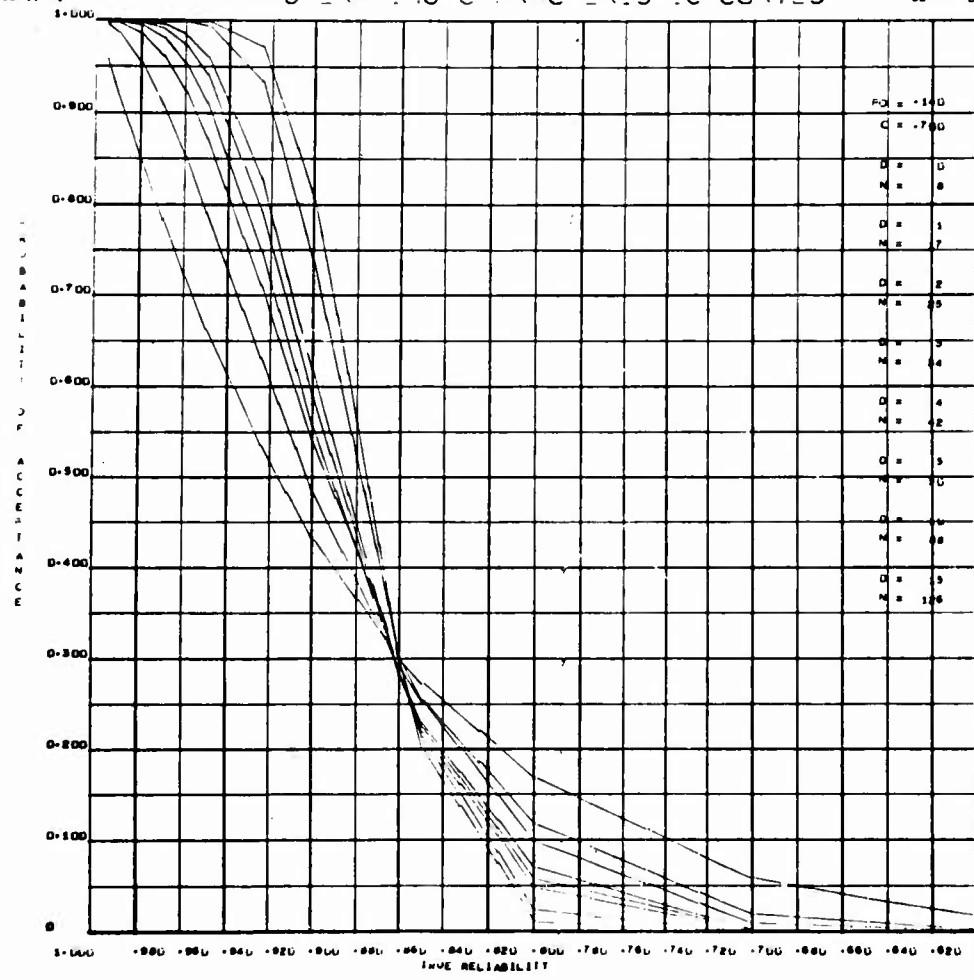
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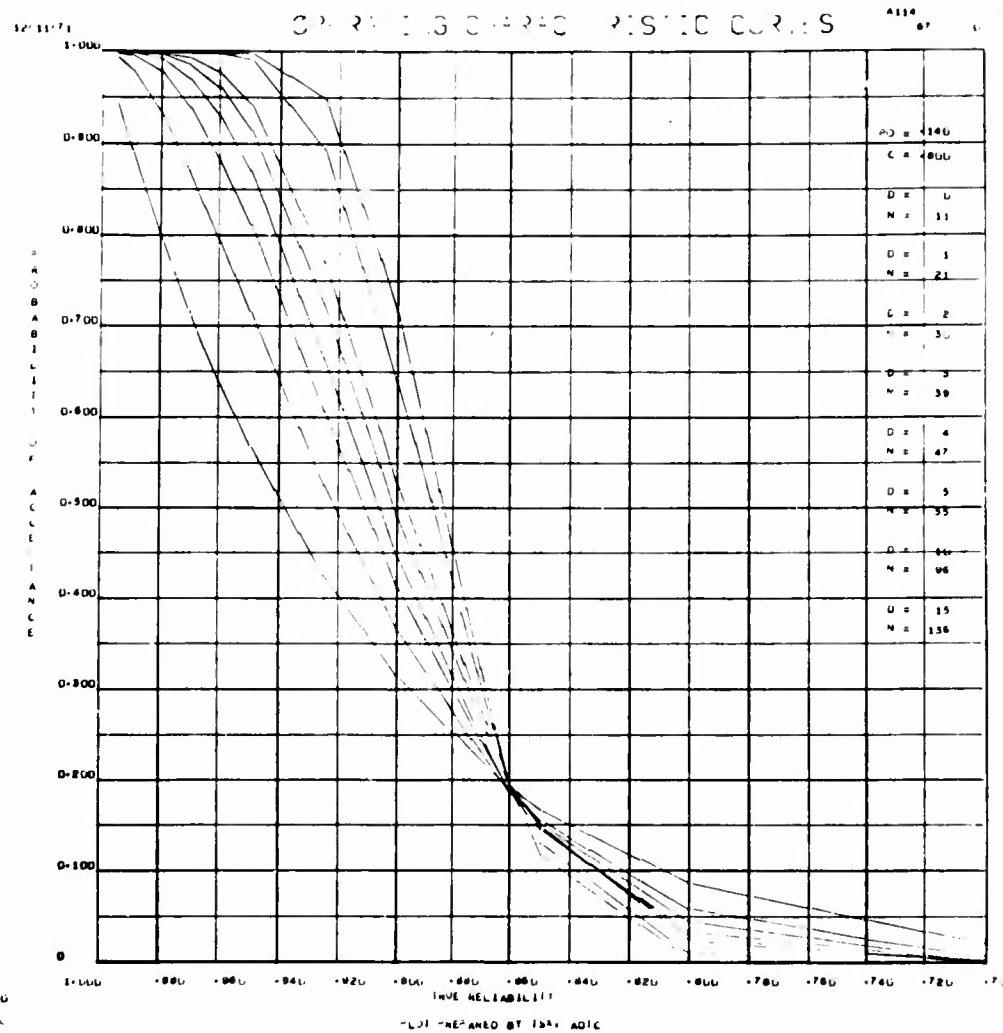


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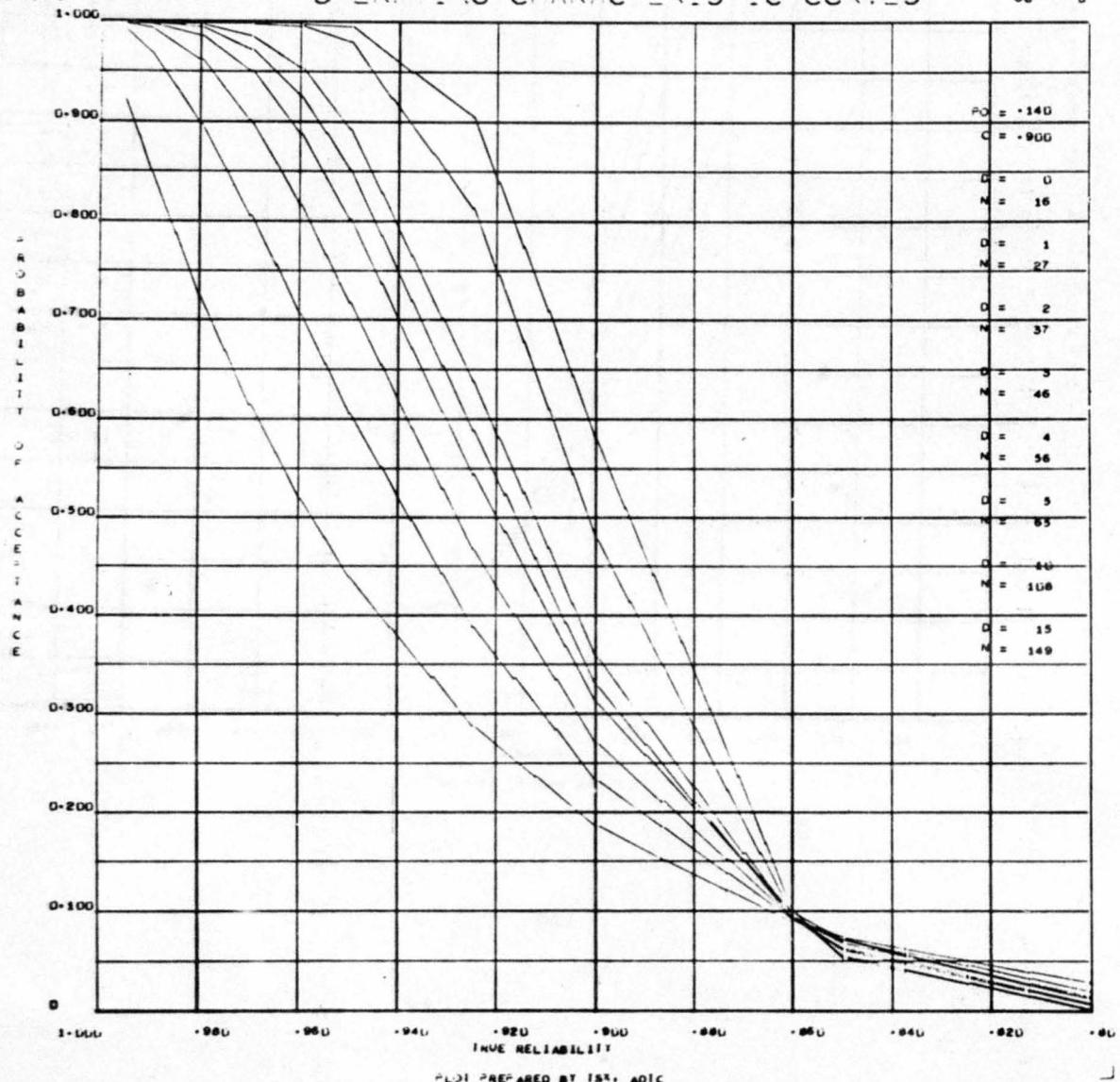
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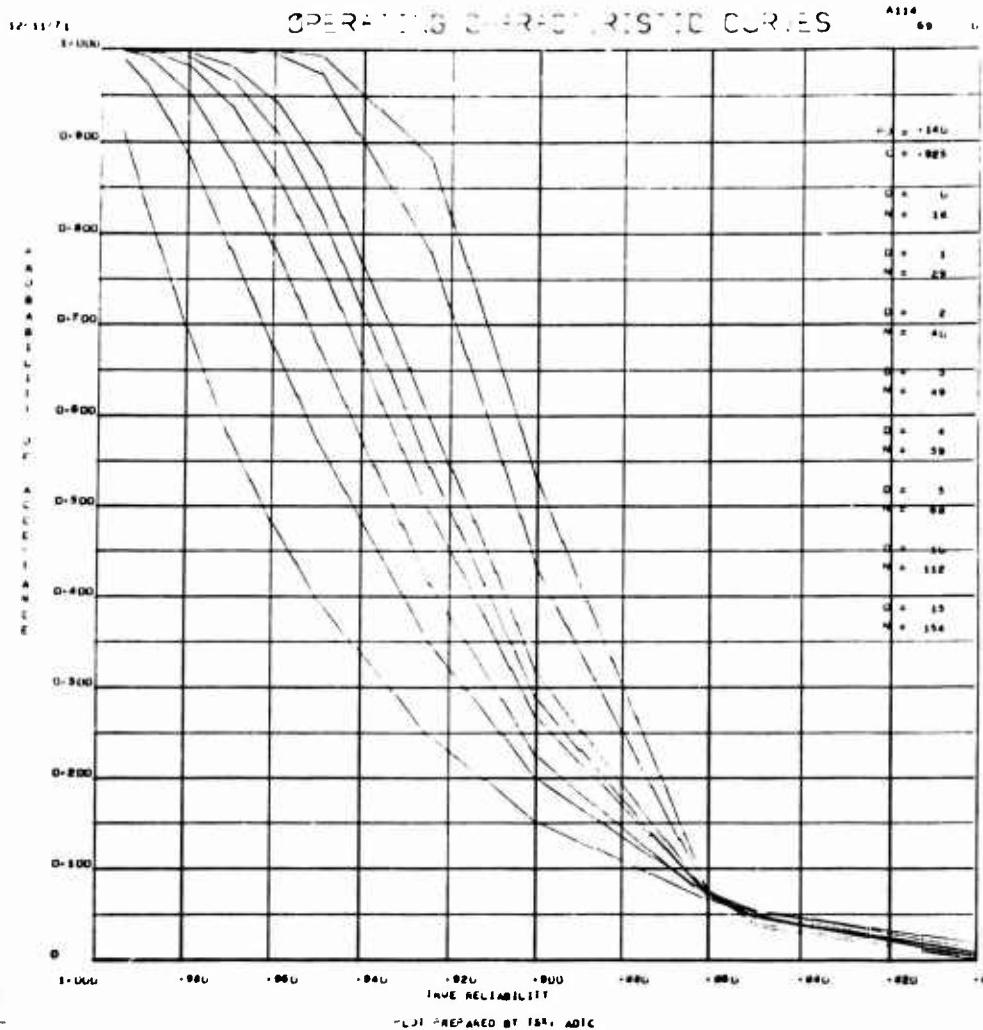
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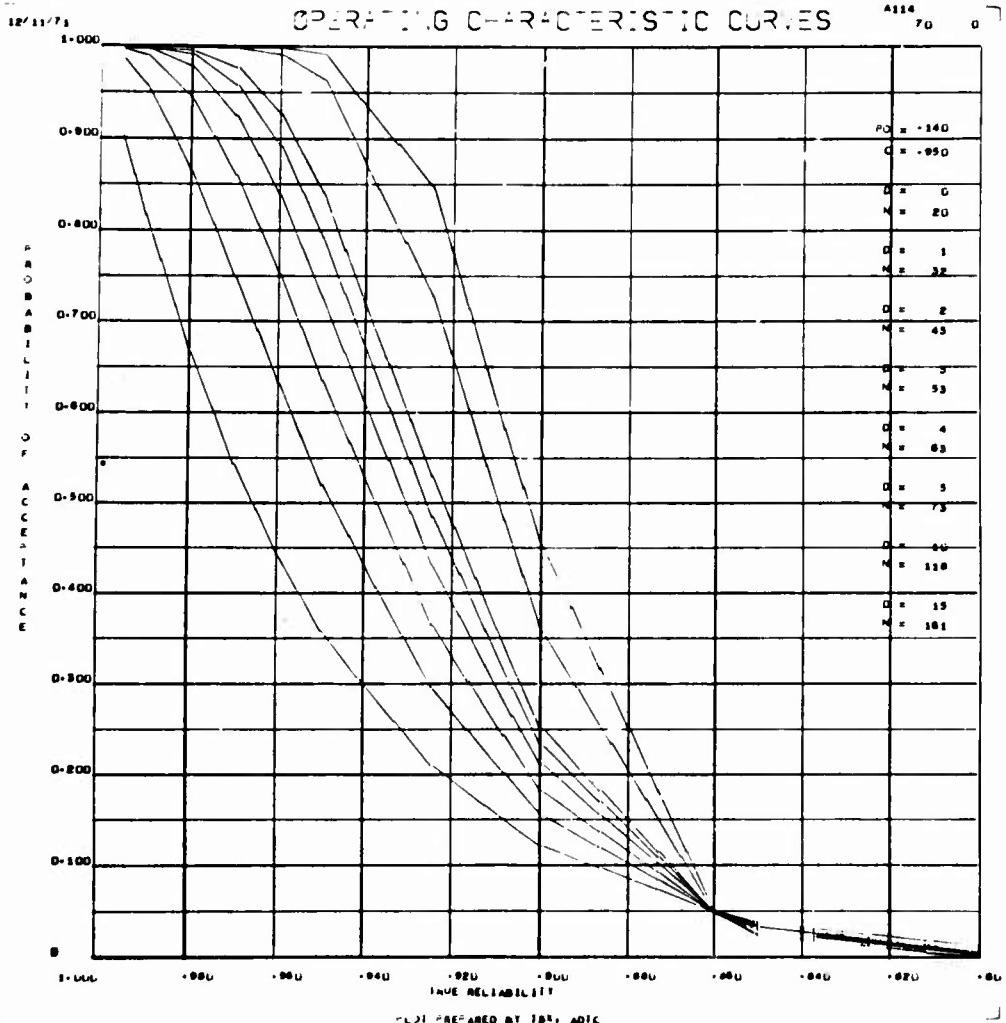
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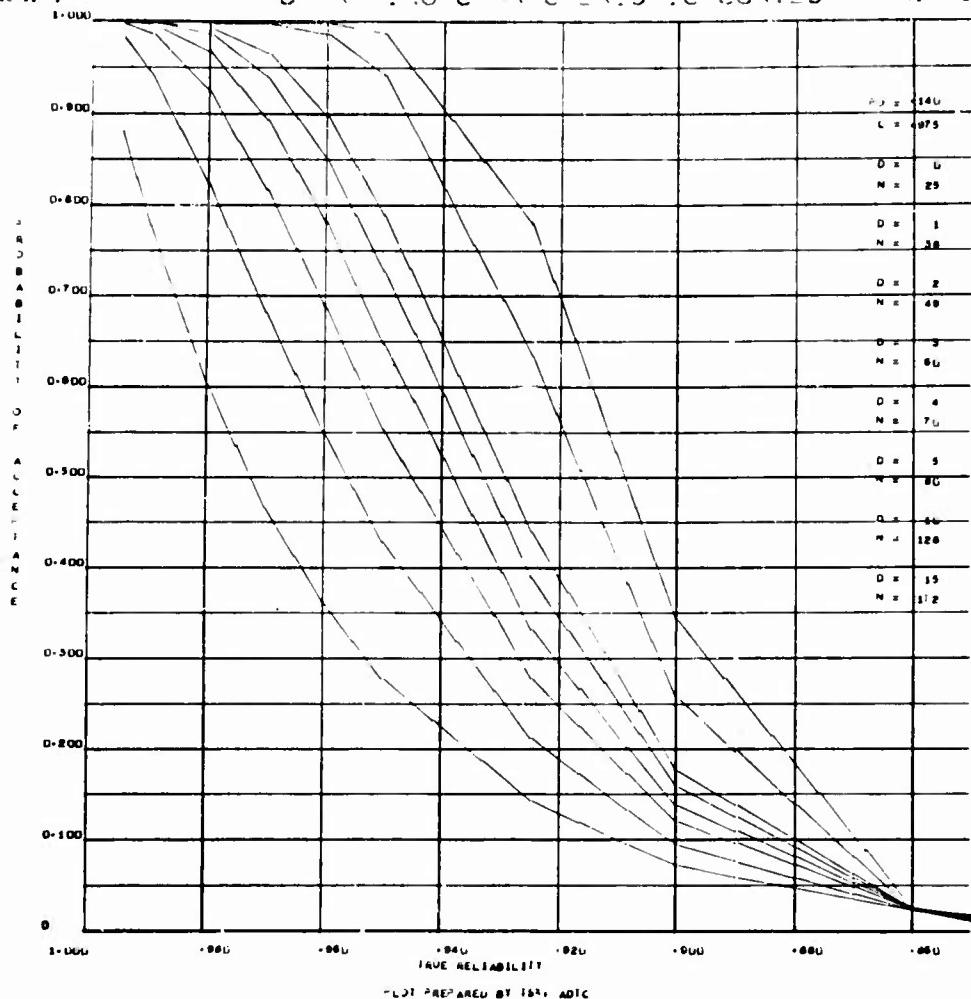


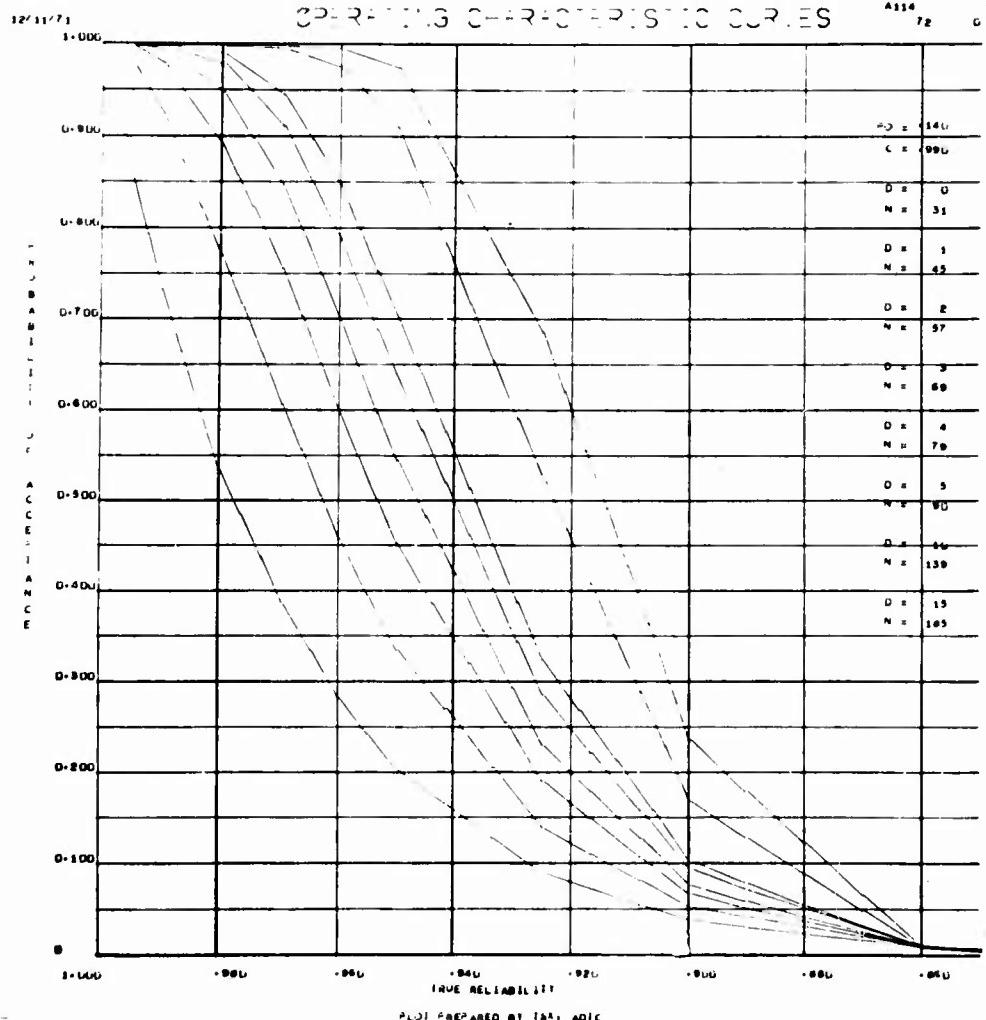
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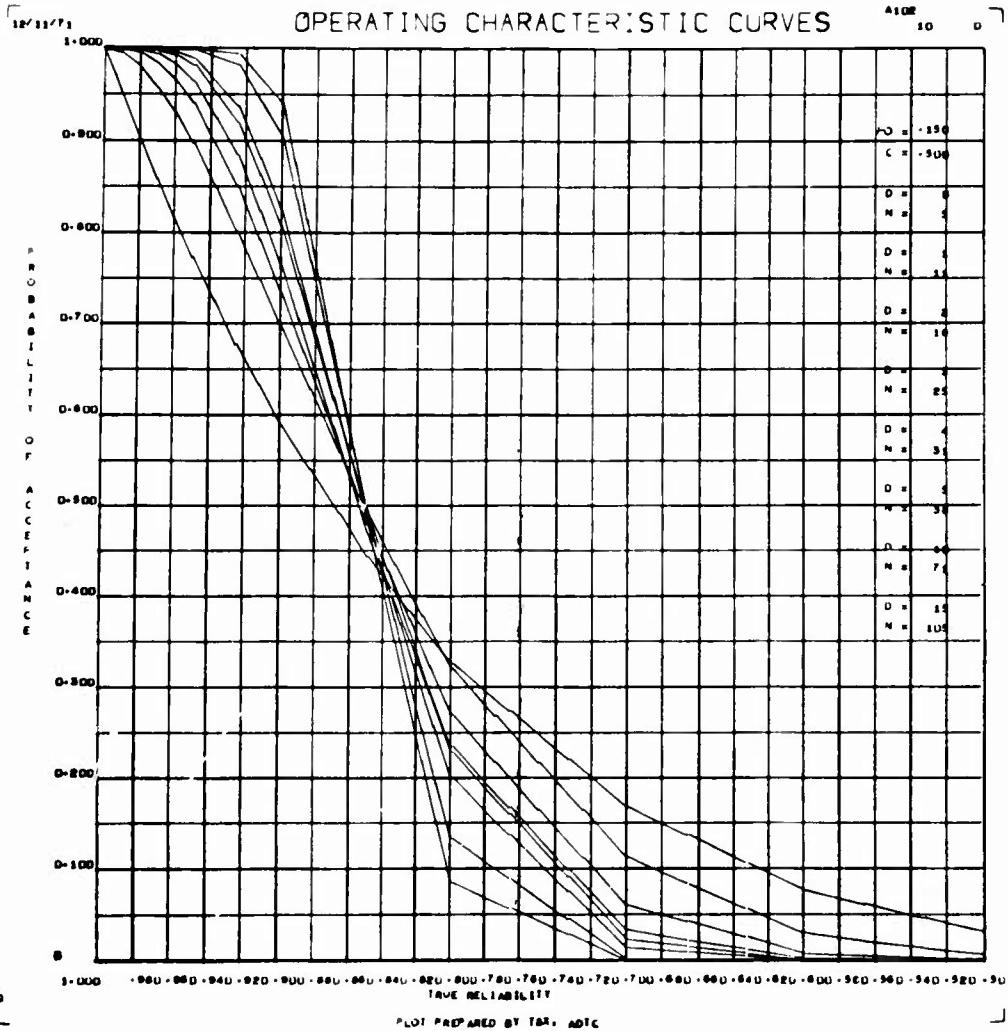
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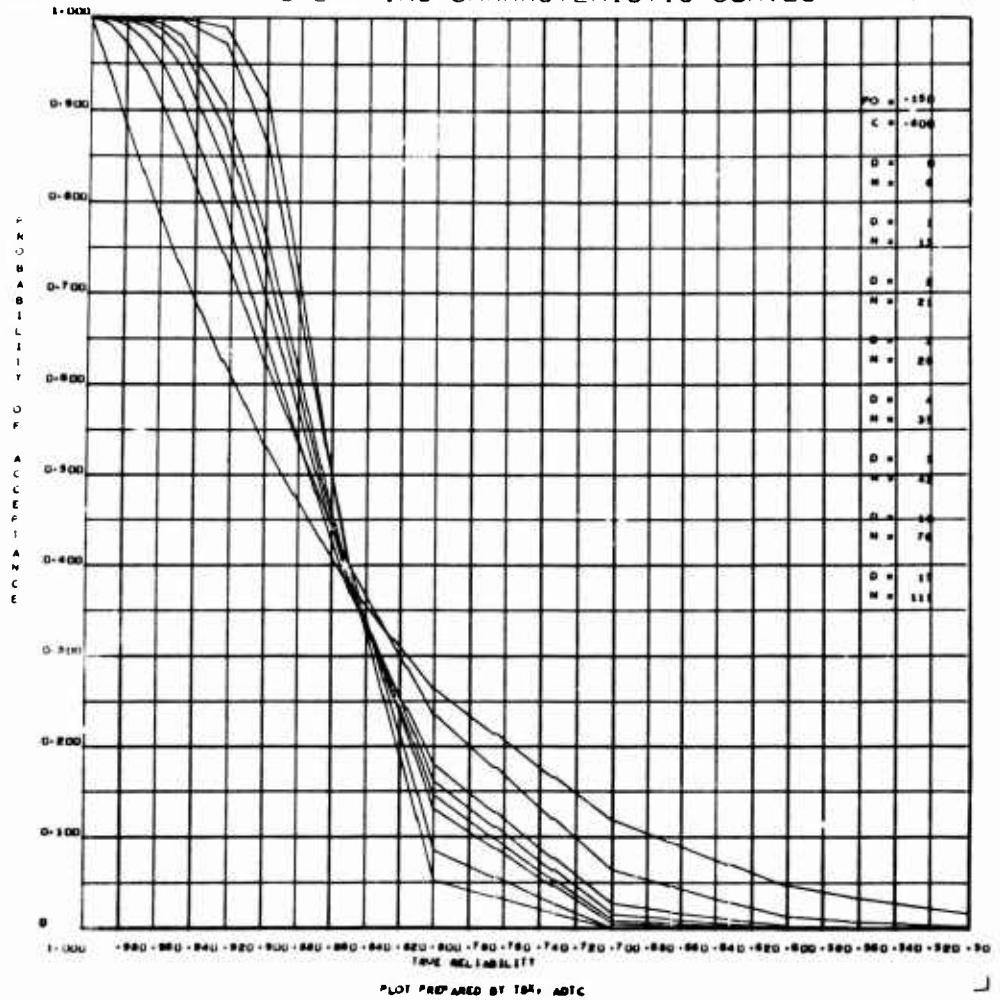


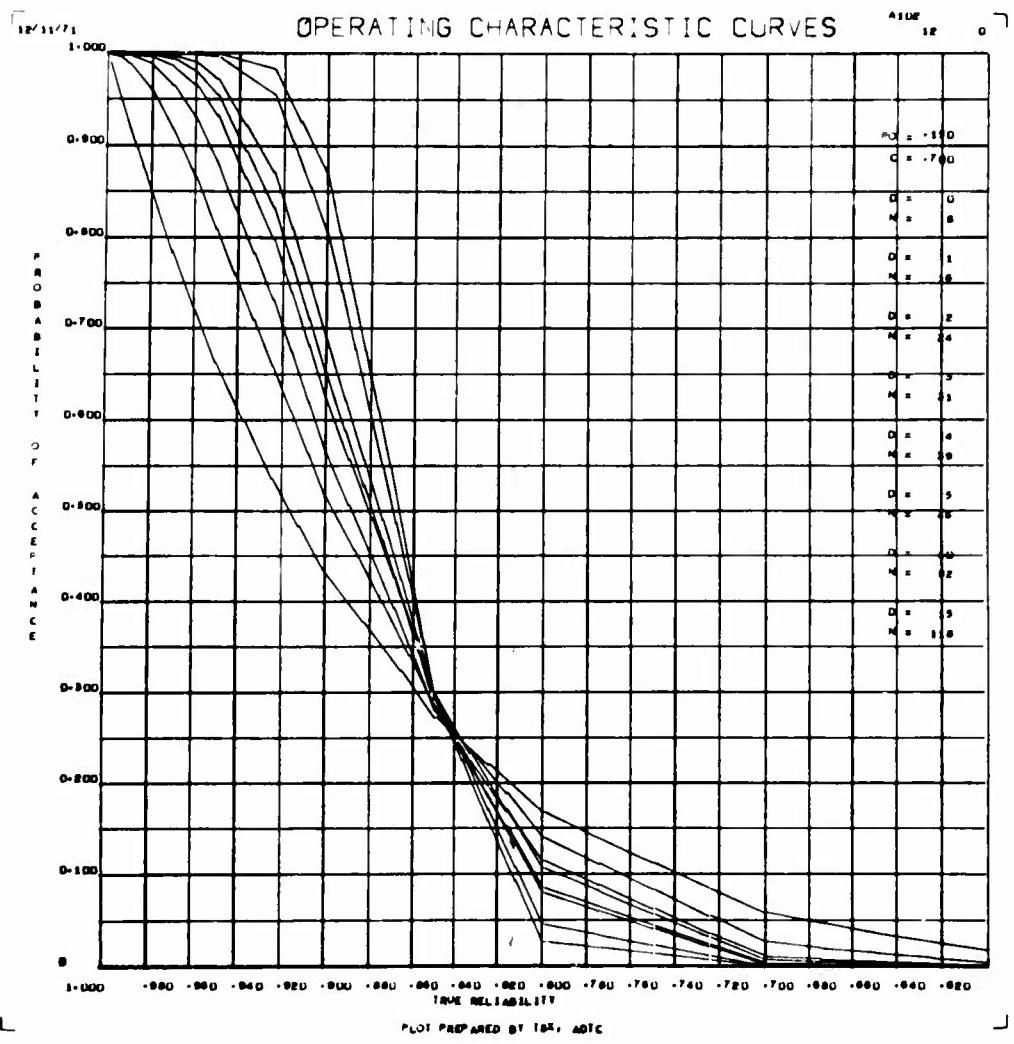
APPENDIX XV

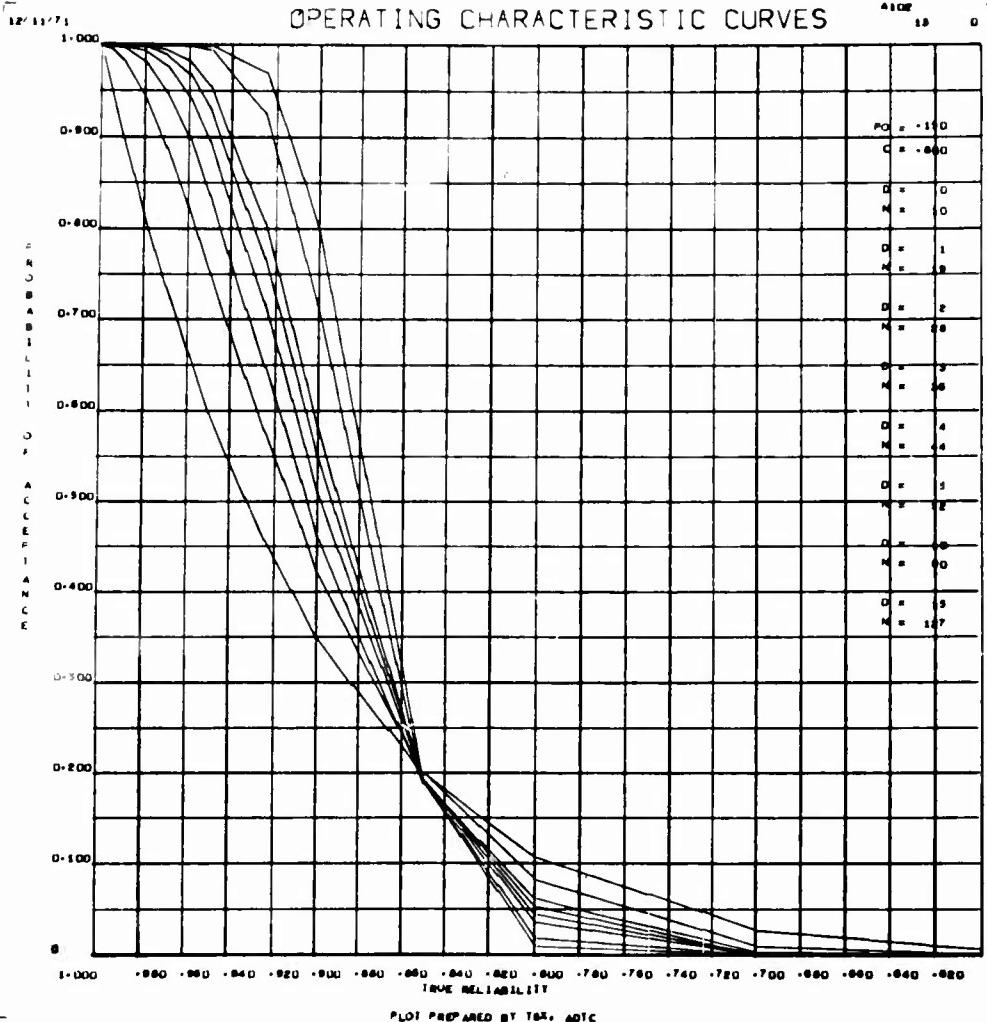
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CURVES ($p_0 = .150$)**

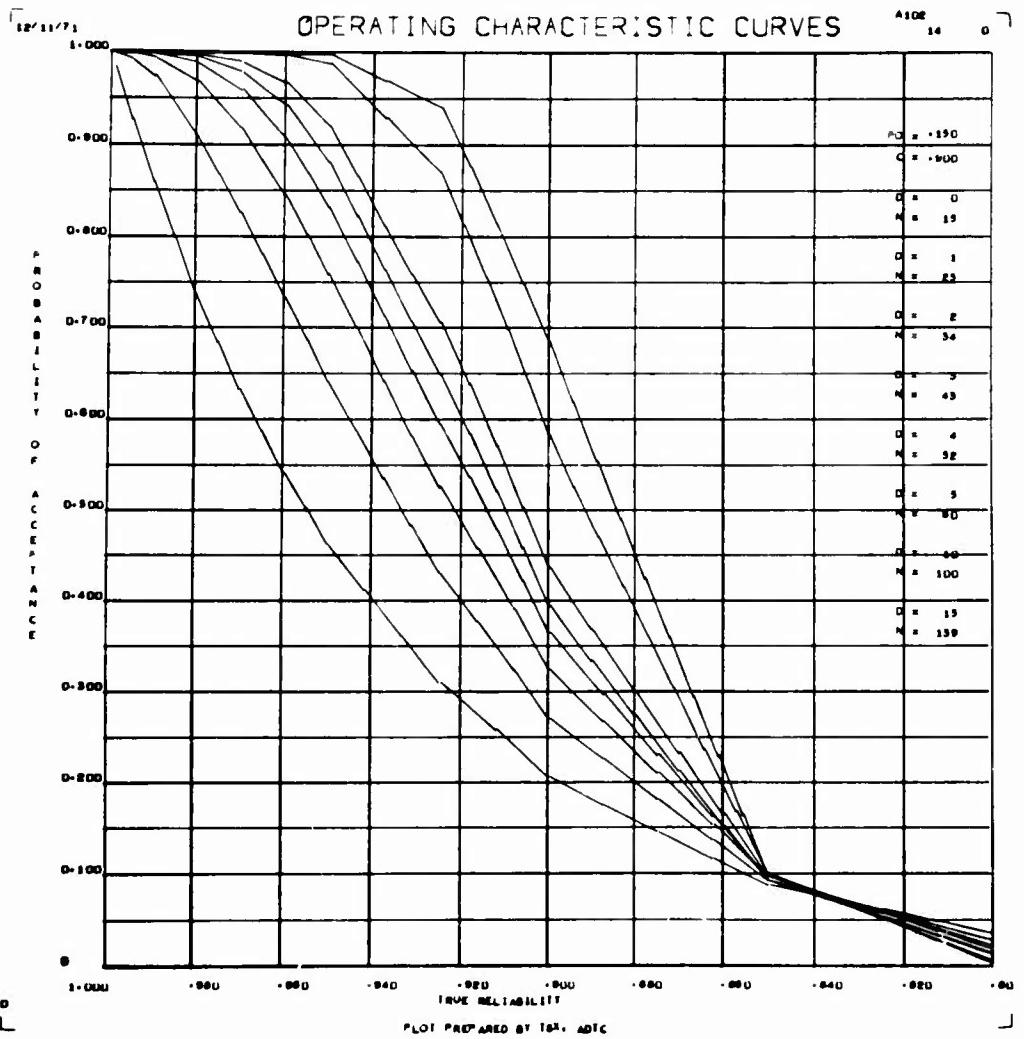


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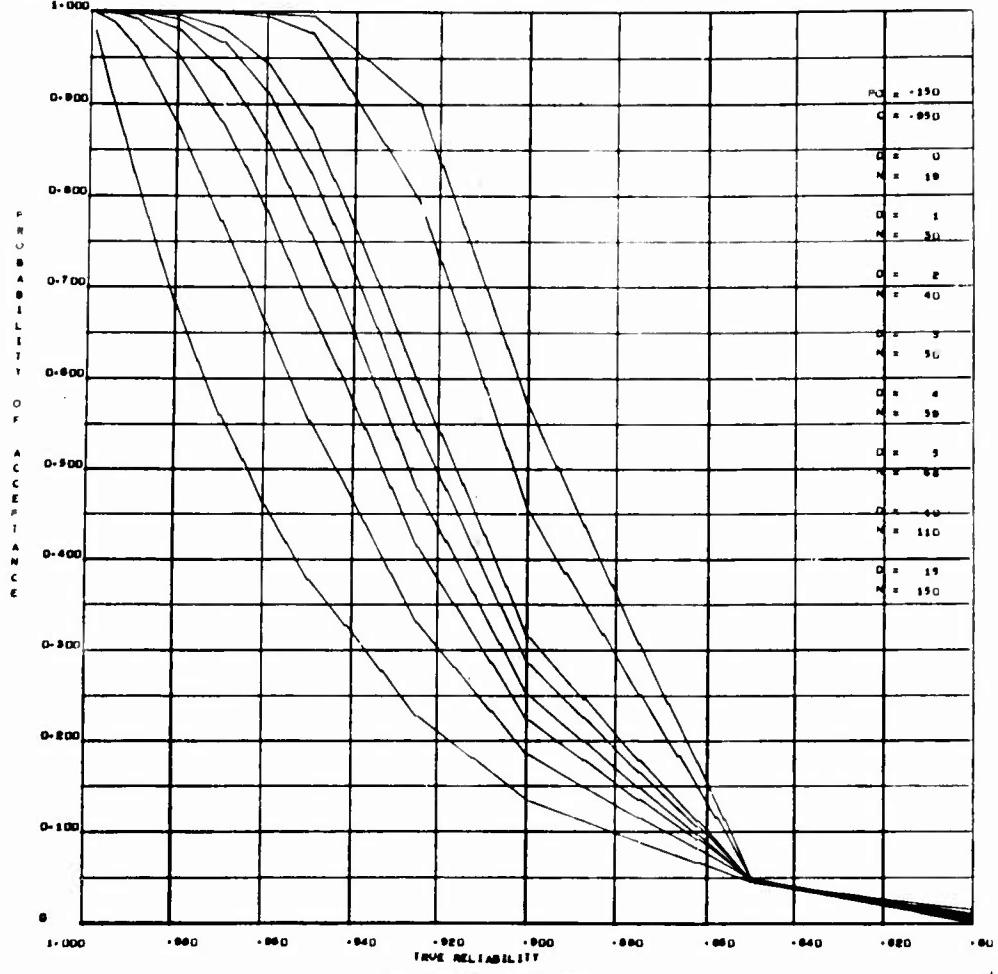




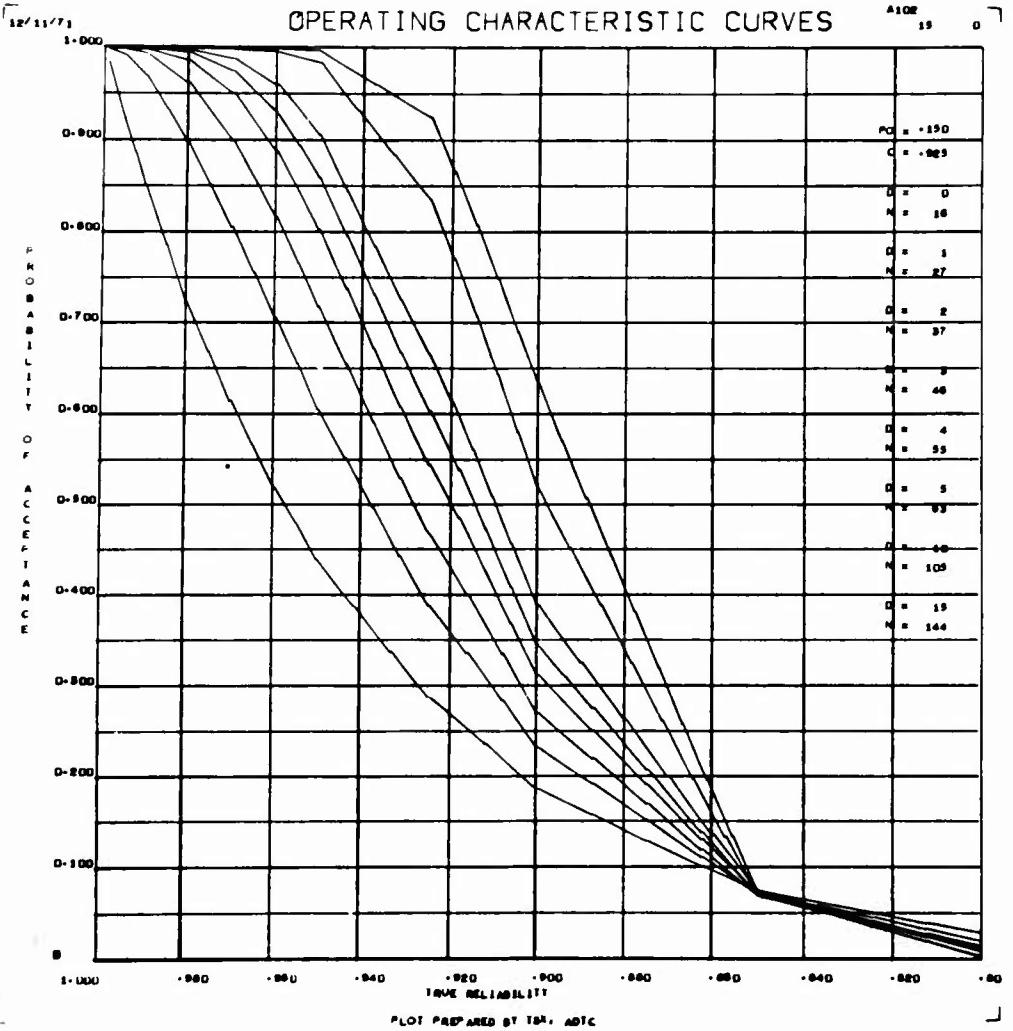
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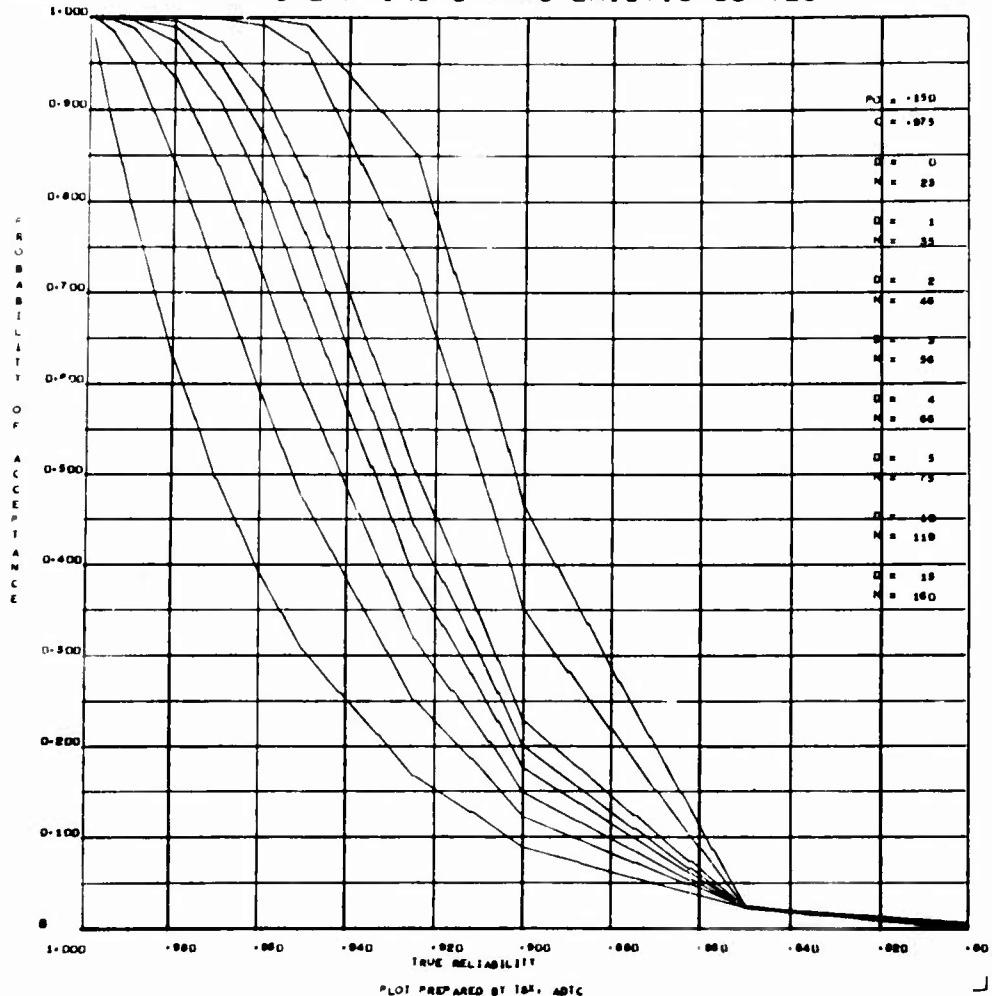
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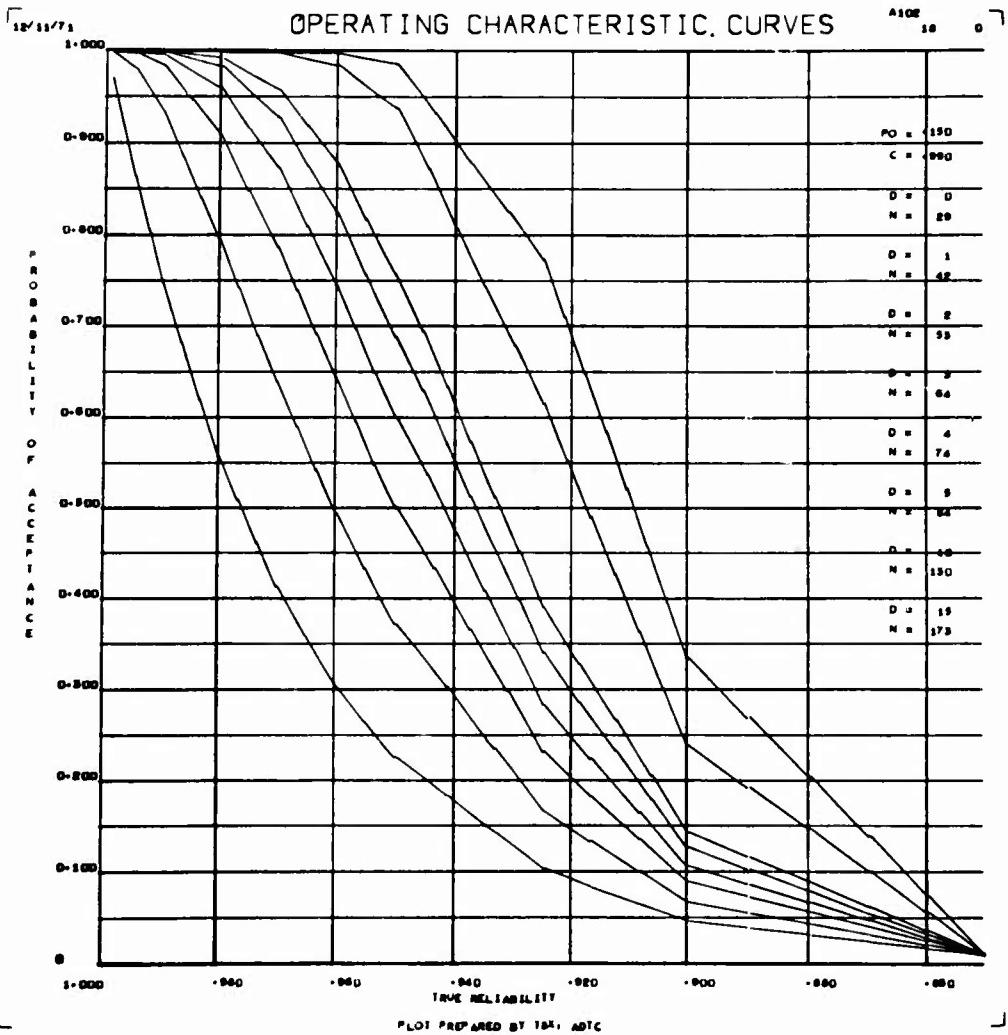


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13. ABSTRACT

Operating characteristic curves are presented which give the probability of a random sample from a binomial population being accepted versus the true reliability of the lot for a given sample size and with the acceptance number of defectives held fast. The curves can be used by statisticians, engineers, and quality assurance workers concerned with attributes testing of large lots of items submitted for testing or with writing specifications for such tests.



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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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BINOMIAL Population Samples						
Attribute Acceptance Inspection						
True Reliability						
Probability of Acceptance						

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